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Lawrence Livermore National Laboratory

University of California Livermore, California 94551

UCRL-AR-110532

Remedial Action Implementation Plan for the LLNL Livermore Site Livermore, California

January 6, 1993

Technical Editors:

M. D. Dresen*
J. P. Ziagos
A. J. Boegel
E. M. Nichols*
J. K. Macdonald*

Contributing Authors:

K. Anderson**
A. J. Boegel
R. O. Devany*
M. D. Dresen*
E. N. Folsom
J. L. Iovenitti*
J. K. Macdonald*
P. F. McKereghan*
C. N. Noyes*

*Weiss Associates, Inc., Emeryville, California
**ICF Kaiser Engineers, San Francisco, California

Environmental Protection Department

Environmental Restoration Division

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1. Introduction

This Remedial Action Implementation Plan (RAIP) was prepared to comply with the requirements of the Federal Facility Agreement (FFA) for Lawrence Livermore National Laboratory (LLNL), Livermore, California (Fig. 1). The RAIP is the first step in the Remedial Design/Remedial Action (RD/RA) process under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The FFA for the LLNL site specifies preparation of a RAIP, which is similar to the U.S. Environmental Protection Agency (EPA) document called the Remedial Design Workplan. This RAIP was prepared by LLNL for the U.S. Department of Energy (DOE) with oversight from the following regulatory agencies: EPA, the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB).

This RAIP is a workplan for the remedies selected for ground water and soil contamination in the Record of Decision (ROD) for LLNL (DOE, 1992). The RAIP was prepared using information from the FFA and an outline prepared by EPA. Specifically, it presents a workplan and schedule for preparation of the Remedial Design (RD) documents that implement the remedial actions for the LLNL Livermore site. The RD documents that will be prepared under this workplan will include process and instrument diagrams and system descriptions, construction schedules, estimated dates for important remedial milestones, and cost estimates for implementing the remedial measures.

Remedial Action (RA) Workplans are also part of the EPA RD/RA process and will be submitted with the Draft RD documents. The RA Workplans will present the RA Team and the Quality Assurance/Quality Control Plan for construction. They will also present the Preliminary Operation and Maintenance Plans and establish monitoring and reporting schedules. In addition, the Health and Safety Plans for construction, operation, and maintenance, and the requirements for offsite shipment of hazardous waste and for project closeout will be included with the RA Workplans.

Other post-ROD documents that will follow the RA Workplans include a Data Management Plan; a Compliance Monitoring Plan, consisting of a Sampling and Analysis Plan; a Quality Assurance Project Plan; and a Contingency Plan, which will describe strategies that would be implemented if discharge limits are exceeded during cleanup.

2. Remedial Design Team and Approach

The organization and members of the LLNL Livermore Site Remedial Design Team are presented in Section 2.1, and the overall approach to implementing the RD/RA process at the Livermore site is discussed in Section 2.2.

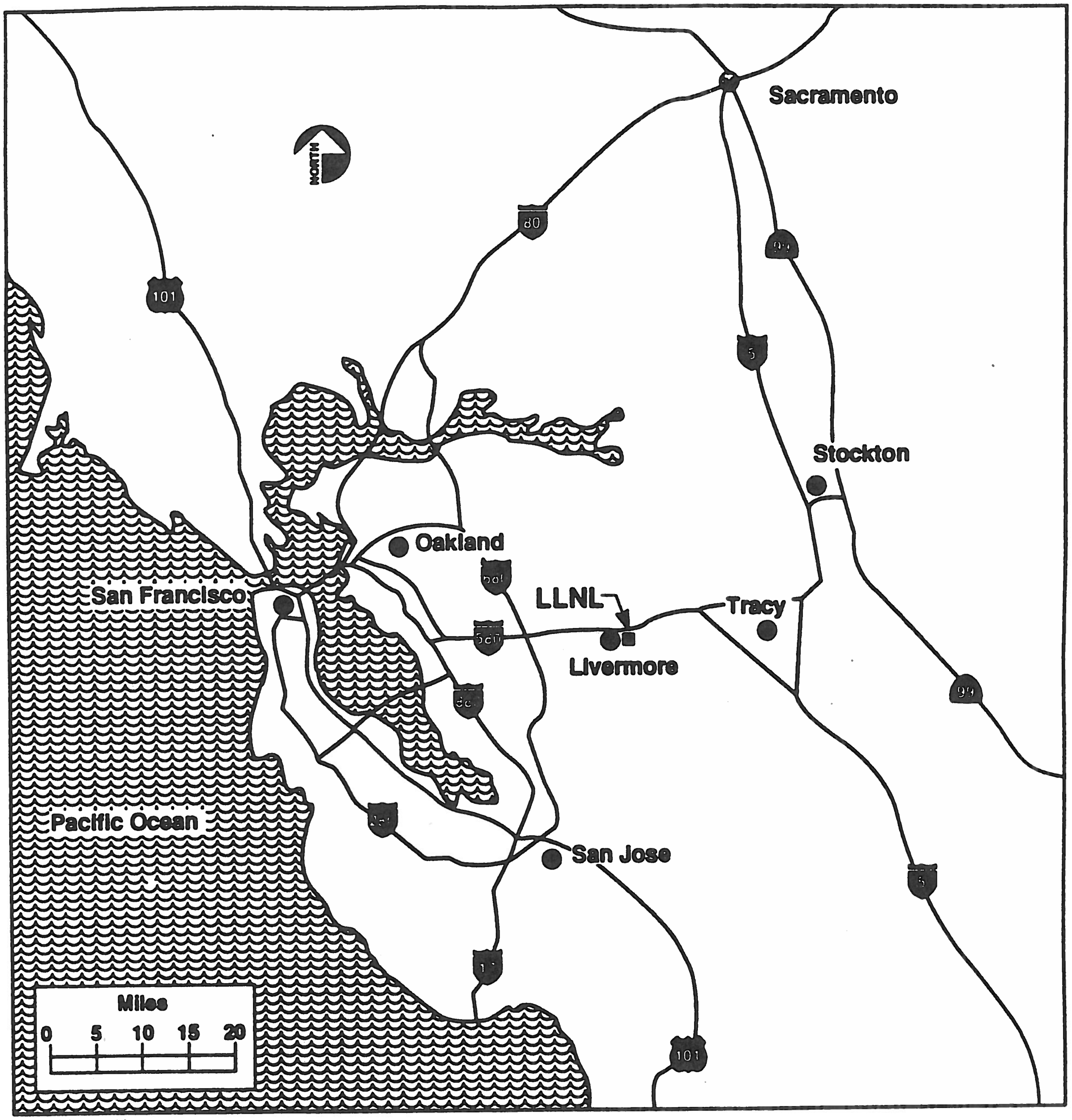

Figure 1. Location of the LLNL Livermore site.

2.1. Personnel and Responsibilities

The key members and organization of the LLNL RD Team are shown in Figure 2. The RA Project Leader for the LLNL site is William A. McConachie, the Environmental Restoration Division (ERD) Leader for the Livermore site Ground Water Project. John Ziagos, ERD Environmental Restoration Section Leader for the Livermore site, will be responsible for regulatory interface, hydrogeology, modeling, and preparation of regulatory documents. A. J. Boegel, ERD Remedial Design and Operations Section Leader, will be responsible for technology evaluation, engineering design, and construction of treatment facilities and pipelines. Dorothy Bishop, Acting Environmental Management Technologies Section Leader within ERD, will be responsible for data management and data quality assurance. Other project personnel and their responsibilities are shown in Figure 2.

2.2. Overall Approach to Remedial Design and Remedial Action Implementation

The RAs described in the ROD for the LLNL Livermore site will be phased-in to determine the actual effectiveness, compared to the predicted effectiveness, of the initial planned extraction wells and treatment systems before proceeding with subsequent phases. As discussed with the regulatory agencies, both the technical and regulatory aspects of the remediation will be conducted in phases. Five RD documents will be submitted for regulatory agency and community review according to the preliminary schedule in Section 5 of this workplan. As discussed in Section 5, the seven planned treatment systems for the 24 initial extraction locations will be constructed over a period of 3 years. This phased implementation is necessary to be consistent with projected funding levels. In addition, the phased approach has technical advantages including:

1) The opportunity to test and optimize specific ground water extraction and treatment system designs prior to employing them at other parts of the site.

2) The opportunity to evaluate extraction well design, efficiency and performance, and the vertical and horizontal extent of hydraulic capture zones, prior to full implementation of the cleanup plan. This will enable optimum development of the extraction well field.

Integral to LLNL's approach to the planned phase-in of RAs are dynamic management of the well field and optimization of the cleanup through field monitoring and modeling. As the initial extraction wells are installed, they will be pumped continuously, and wells and piezometers in the surrounding vicinity will be monitored to determine actual hydraulic capture areas and optimum extraction rates. As discussed in the Proposed Remedial Action Plan (PRAP, Dresen *et al.*, 1991) and the ROD, if the hydraulic capture objectives of a particular well or wells are not met, then additional wells will be installed to achieve complete plume capture and/or source remediation. Hydraulic and chemical data from each phase of well installation will be used to refine the design and implementation of the subsequent phases. Strategies for implementing the dynamic well field management and optimization include:

- Periodically producing three-dimensional representations of the contaminant distributions in the affected areas.

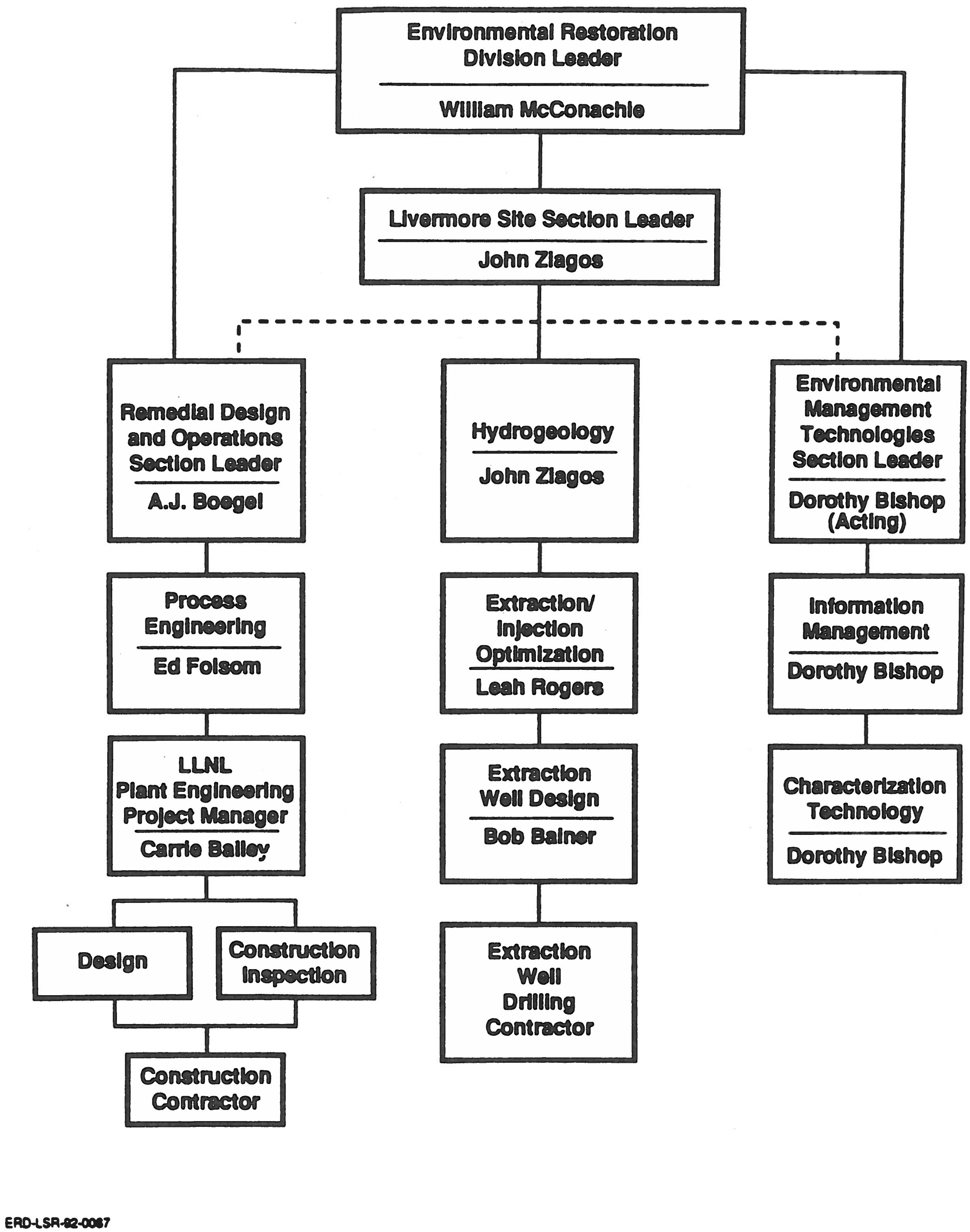

Figure 2. LLNL Remedial Design Team.

- Analyzing the piezometric head distributions within, above, and below the depth interval(s) that are being pumped.
- Adjusting pumping and injection rates and locations when necessary to improve the progress of cleanup while maintaining hydraulic control of the contaminant plumes.

Simulations of ground water flow and contaminant transport will be used to supplement the interpretation of field data and aid in the decisionmaking process. Numerical ground water flow and transport modeling will be conducted to select the optimum locations for extraction and injection wells, and to predict the vertical and horizontal hydraulic capture zones and contaminant mass removal for each extraction well.

The extraction well field will be managed dynamically by varying pumping/injection rates and locations to prevent the formation of hydraulically stagnant zones and to maximize contaminant mass removal. Potential stagnation zones will be determined by monitoring water levels during extraction, and ground water flow modeling will be used to develop dynamic pumping strategies that will eliminate long-term stagnation zones. LLNL also plans to reinject and/or recharge treated ground water to eliminate stagnation zones and flush contaminants more rapidly from high concentration areas. Contaminant transport modeling will be used to select the optimal extraction and injection locations and rates to increase contaminant mass removal and reduce overall cleanup time. LLNL will attempt to minimize dilution of contaminants and maximize treatment efficiency within reasonable limits when designing the cleanup.

LLNL is conducting source investigations in 13 areas of the LLNL site. The results of these investigations are reported in LLNL *Monthly Progress Reports* as they are completed. If it is determined that an area requires vadose zone or ground water remediation that is not already accounted for under the ROD for the LLNL site, alternative remediation approaches will be evaluated and reported in a *Monthly Progress Report* or in a separate report. If the preferred remediation is significantly different from that described in the ROD, then an amendment to the ROD will be prepared with regulatory agency oversight.

Modeling will also be used to determine whether vadose zone contaminants will require remediation. After contaminants in the vadose zone are sufficiently characterized, modeling will be conducted to evaluate whether the vadose zone contaminants would impact the underlying ground water in concentrations above the maximum contaminant level (MCL). If such a potential exists, remedial alternatives will be evaluated and implemented with regulatory agency oversight. If the preferred alternative is sufficiently different from vadose zone alternatives in the ROD, an amendment to the ROD will be prepared.

As specified in the ROD, the progress of the cleanup will be reviewed with the regulatory agencies at least every 5 years. This will allow assessment and implementation of new remediation technologies as they are developed. New information, such as the discovery of additional sources or improved methods of assessing remediation performance, will be incorporated into the 5-year reviews. The overall LLNL and DOE philosophy of the remediation is to achieve a rapid, efficient, and cost-effective cleanup.

3. Remedial Design Criteria

The RA criteria for ground water cleanup are described in Section 3.1, and those for the vadose zone are described in Section 3.2.

3.1. Ground Water

Ground water remediation at LLNL will involve extraction, piping water to a treatment system, treatment, and discharge of the treated water. Hydraulic control and cleanup of the contaminants in ground water will be achieved by placing extraction and recharge wells at strategic locations within the plume and in source areas. The locations and possible designs of the initial planned ground water extraction wells are described below.

3.1.1. Extraction Locations and Well Designs

3.1.1.1. Extraction Locations

Since selection of the 18 extraction locations presented in the PRAP, and during the process to finalize the ROD, sitewide extraction locations have been further evaluated using the computer model CFEST. Numerical simulations of ground water flow and contaminant transport were conducted to determine the optimal configuration of extraction and injection wells. The objectives of this modeling were to reduce total volatile organic compound (VOC) concentrations to less than 5 parts per billion (ppb) within a 50-year period, and to arrest further westward migration of the contaminant plume. Because modeling is an important resource to the project, the RA Workplan will include references to reports that contain the details of the modeling conducted for the project.

As discussed in the ROD, at least 18 extraction locations are necessary to achieve the cleanup objectives. Based on the results of recent numerical ground water flow and transport modeling, three new extraction locations (numbers 19, 20, and 21 on Fig. 3) have been added on the LLNL site to expedite the ground water cleanup. Three additional extraction locations (numbers 22, 23, and 24 on Fig. 3) have also been added along Arroyo Seco, west of Vasco Road, to mitigate potential southerly plume migration that may result from agricultural pumping south of East Avenue. Data regarding the rationale for the initial 24 extraction locations are presented in Table 1. In the future, additional extraction and recharge locations may be added to expedite the cleanup, depending on the actual size of capture areas, the rates of contaminant mass removal, and the results of more detailed modeling.

The extraction locations will be strategically placed near contaminant plume margins to intercept and hydraulically control all ground water originating from LLNL with VOC concentrations exceeding MCLs (Fig. 4). In addition, ground water will be extracted from source areas and areas where ground water VOC concentrations are above about 100 ppb to expedite cleanup. Field locations of extraction and recharge wells will depend on the local hydrogeology and ground water chemistry, as well as logistical factors, such as drill rig access and locations of underground utilities. Where suitable wells exist, LLNL plans to use the extensive network of existing monitor wells to extract ground water and monitor water levels and changes in contaminant concentrations during the cleanup.

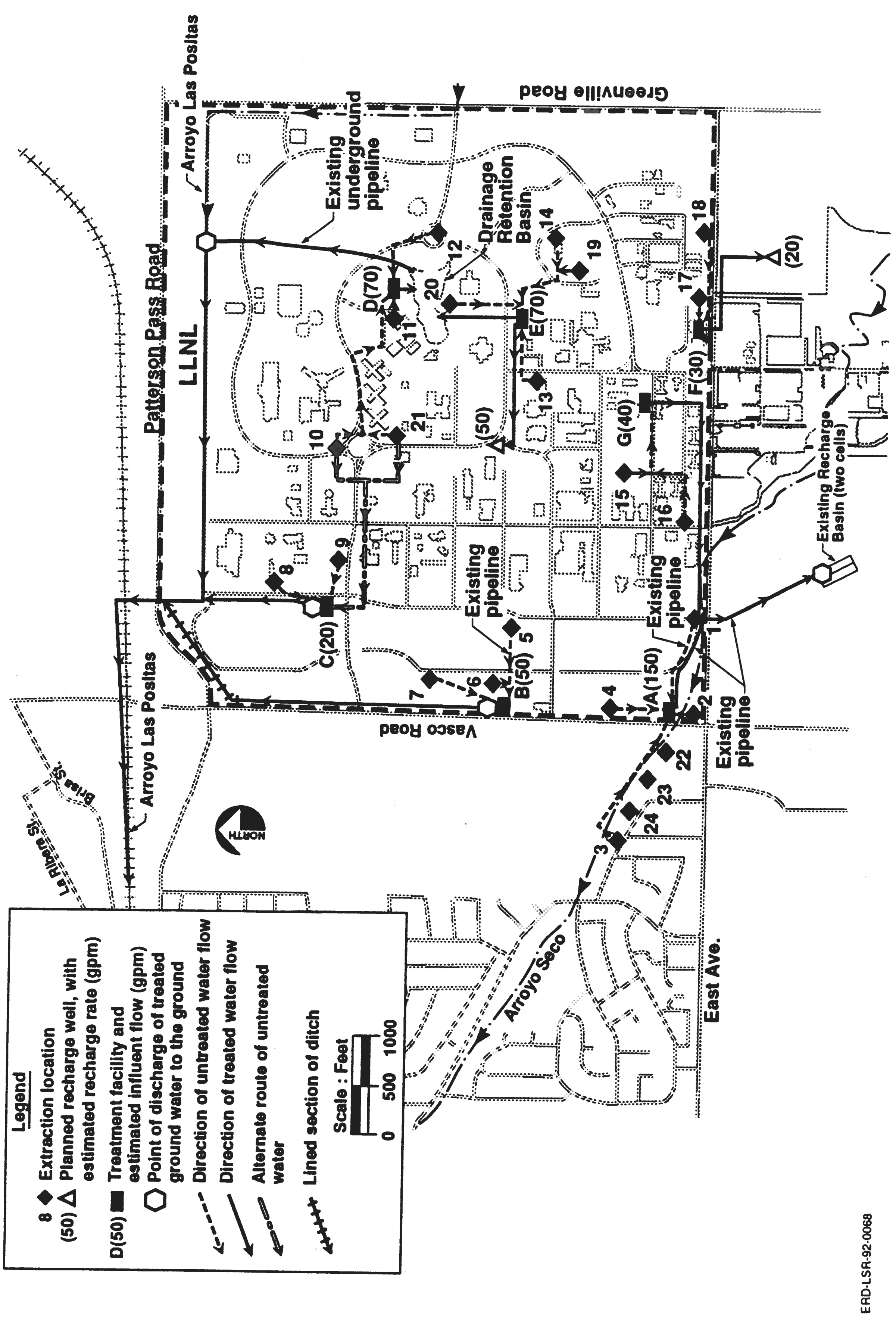

Figure 3. Planned ground water extraction, recharge, and treatment facility locations.

Table 1. Description of initial extraction well locations, LLNL Livermore site.

Extraction location[1]	Approximate interval to be remediated (ft below ground surface)	Number of water-bearing zones[2]	Purpose/comments
1	79-179	5	Source area control
2	90-140	3	Southern plume margin control
3	100-150	2	Downgradient plume control
4	70-185	5	Site boundary plume control
5	65-125	3	Source area control
6	60-125	2	Downgradient plume margin and site boundary control
7	120-130	1	Downgradient plume margin control
8	75-85	1	Plume margin control
9	55-90	2	Downgradient source area control
10	95-125	2	Source area control
11	140-160	5	Source area control
12	60-130	4	Source area control
13	95-130, 155-200	4	Downgradient source area control
14	95-150	3	Source area control
15	80-160	4	Source area control
16	95-170	4	Source area control
17	100-200	4	Southern plume margin control and fuel spill remediation
18	110-125	1	Source area and site boundary control
19	85-210	4	Source area control
20	85-155	3	Source area control
21	85-105	1	Source area control
22	90-190	3	Mitigate offsite agricultural pumping
23	90-190	3	Mitigate offsite agricultural pumping
24	95-190	3	Mitigate offsite agricultural pumping

[1] Extraction locations are shown in Figure 3.

[2] A water-bearing zone is defined as saturated permeable sediment at least 3 feet thick with at least 5 feet of low-permeability sediment above and below.

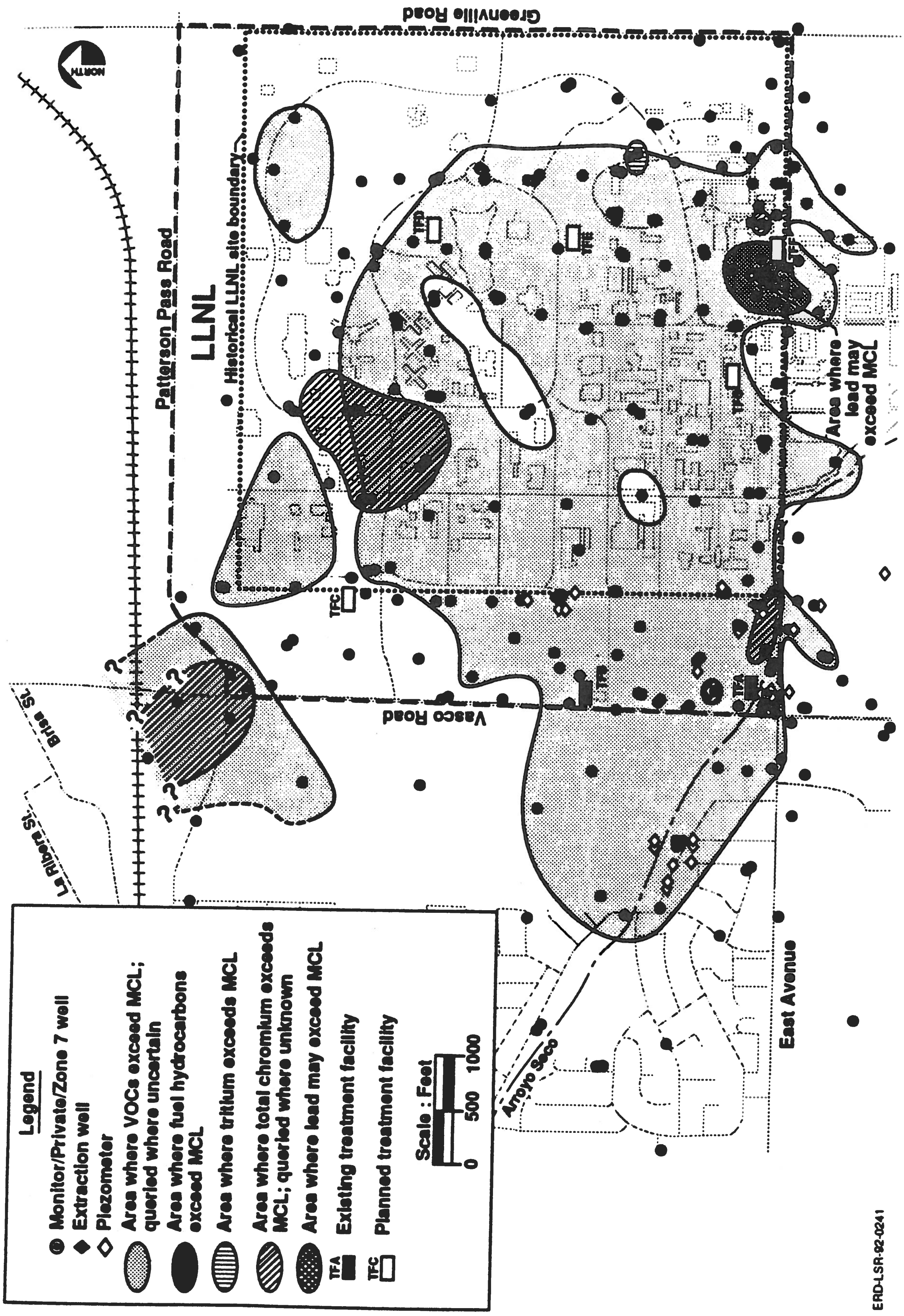

Figure 4. Areas where ground water contains VOCs, total chromium, fuel hydrocarbons, tritium, or lead concentrations exceeding the maximum contaminant level (MCL).

3.1.1.2. Extraction Well Designs

Several extraction wells have been installed at the LLNL site as part of EPA-approved pilot studies, as discussed in Sections 4.1.1.1 through 4.1.1.3. One of these wells is EW-415, an engineered extraction well that has been effectively capturing a significant portion of the VOCs in the Southwest Corner/Offsite Area (extraction location No. 1 on Fig. 3). The water from EW-415 is treated at pilot Treatment Facility A (TFA), located near Vasco Road. EW-415 was designed using one of three approaches (discussed below in this section) that have been evaluated for LLNL extraction wells. This well is fully screened and sand-packed over a 100-foot interval that spans five water-bearing zones containing VOCs (a water-bearing zone is a sand or gravel layer greater than about 3 feet thick). Compared to wells screened only in permeable zones, its fully screened and sand-packed design is believed to be more effective in removing VOCs from both coarse- and fine-grained sediment, such as near source areas at LLNL (Remedial Investigation, Thorpe *et al.*, 1990). However, the fully screened and sand-packed design of this well has limitations that were recognized before the well was installed, including:

- Inability to pump a zone, or zones, selectively and/or at different flow rates.
- Difficulty in assessing the flow and VOC mass removal rates for individual zones.
- The potential to clog the well screen and treatment systems by producing fine-grained sediment in water pumped from the screened silts and clays.

In view of these limitations, LLNL has considered alternative designs for future extraction wells. Analyses of saturated sediment and ground water at LLNL indicate that VOCs are present in all saturated sediments within a VOC plume that are within several hundred feet of a source area (Thorpe *et al.*, 1990). However, at greater distances from the source, VOCs are limited to the more permeable sediments and the first few feet of fine-grained sediment adjacent to the permeable zones (Bishop *et al.*, 1990). Therefore, as an alternative to the EW-415 design, LLNL plans to install a single well in each permeable interval requiring remediation at extraction locations that are more than a few hundred feet from source areas. A cluster of several wells may be installed at many of the locations shown in Figure 3 to capture the full vertical thickness of the plume. The general design of these wells, each completed in a single contaminated water-bearing zone, is shown in Figure 5. This approach offers maximum flexibility for assessing VOC mass removal from each zone, and enables the pumping of each zone at an optimum flow rate and/or different flow rates over time. In addition, the shutdown of one well in the cluster would not result in cessation of all extraction at that location.

The third potential extraction well design is to install a single well completed in two or more permeable zones, with grout seals installed in the well annulus between the screened intervals (Fig. 6). This design would allow isolation of an individual zone, or zones, with packers for selective pumping and sampling for VOCs. However, it does not provide the same degree of flexibility as would individual, single-zone completion wells. In addition, LLNL's experience installing wells of this type indicates it is difficult to install multiple grout seals in a single well without risk of grouting portions of the well screen, especially where the vertical distance between screens is less than 7 to 10 feet.

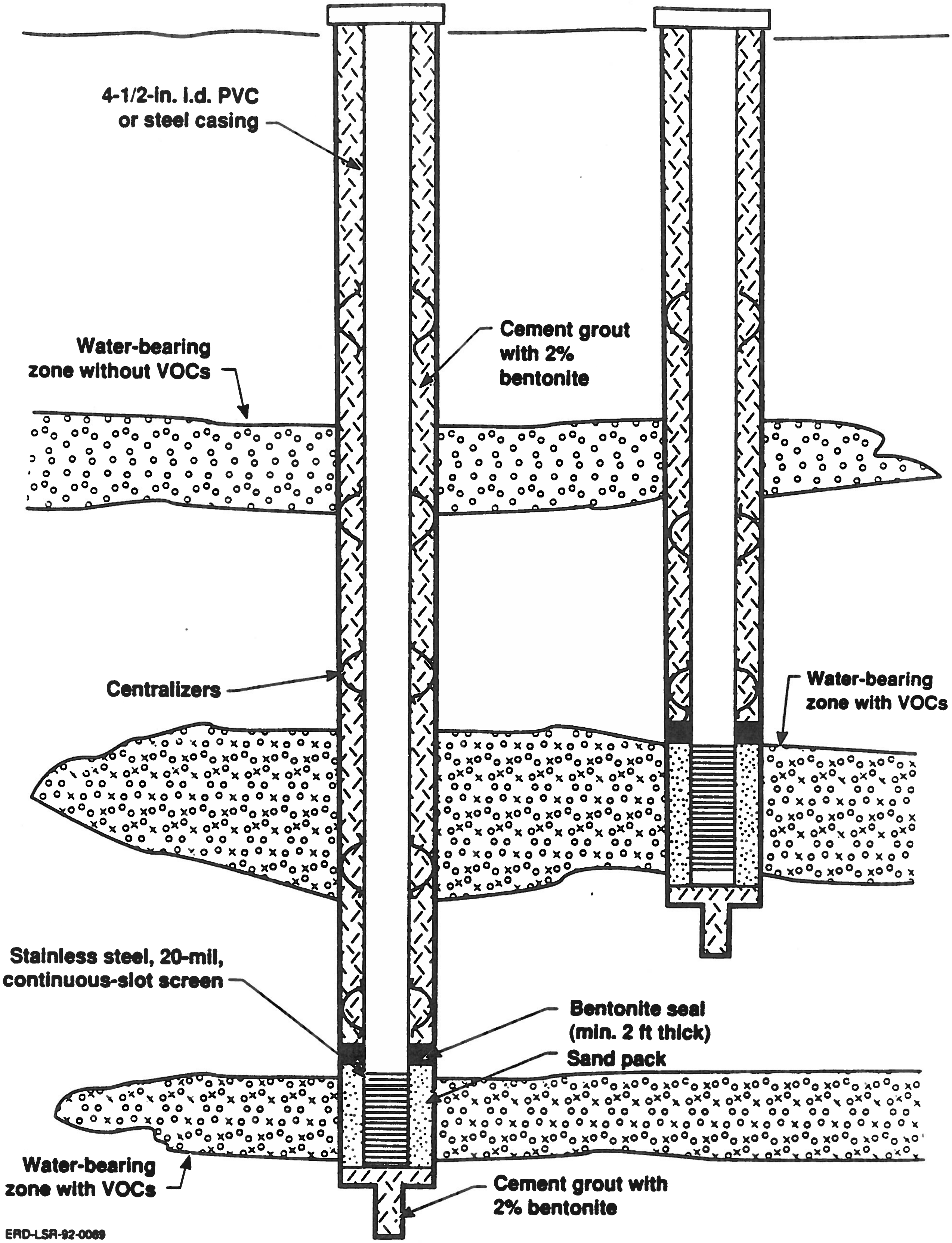

Figure 5. Schematic diagram of single-screen wells in an extraction well cluster.

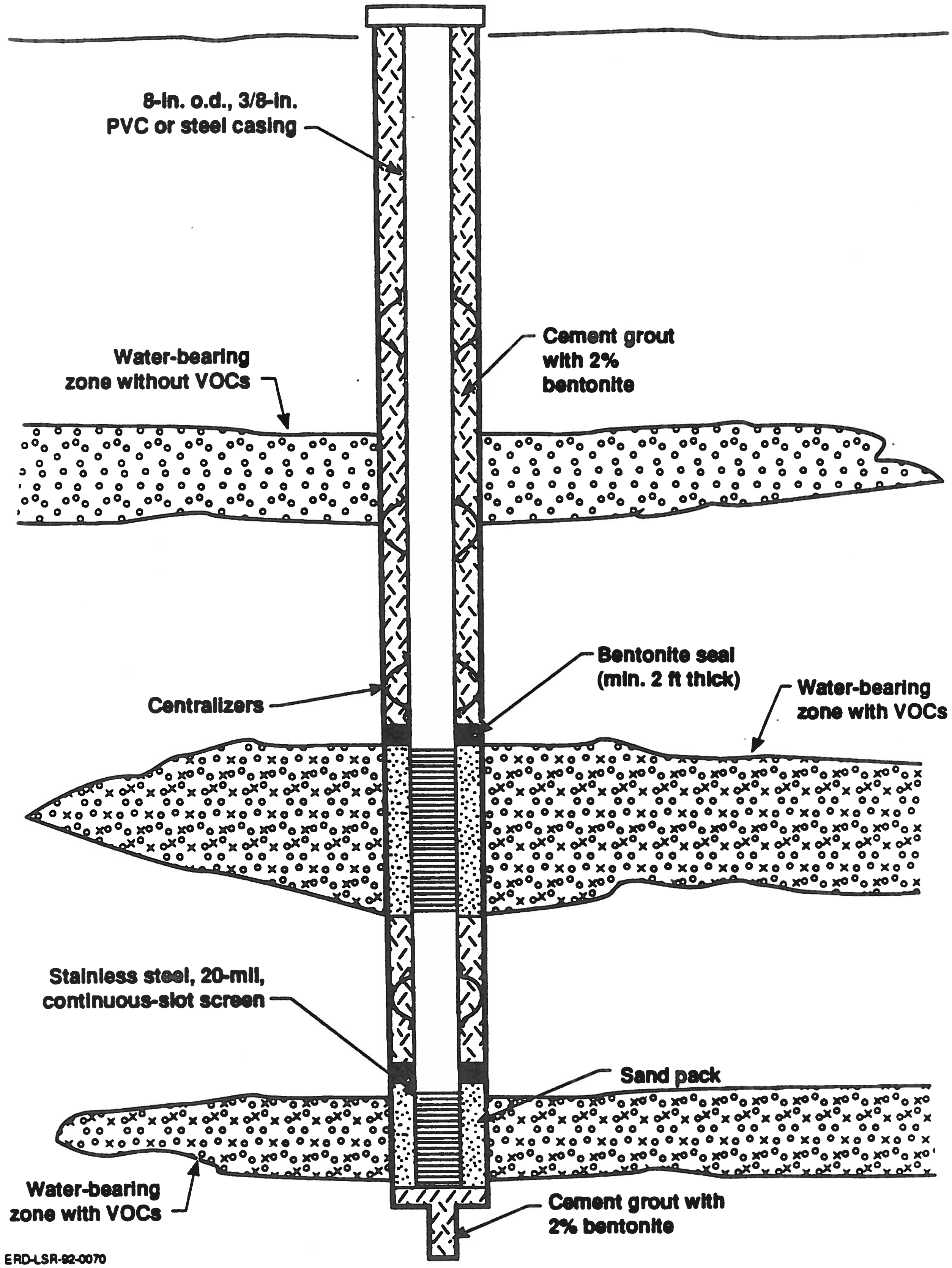

Figure 6. Schematic diagram of extraction well completed in multiple zones.

To mitigate the difficulties associated with installing multiply-screened wells, LLNL plans to limit each well of this type to two or perhaps three screens. In these wells, grout seals would be installed only when their minimum thickness is about 7 to 10 feet. These measures will reduce the risk of grouting portions of the well screen and will provide additional flexibility compared to the fully screened and sand-packed single-well design of EW-415.

The design approach used at each extraction location will be based on physical conditions, such as available surface space, underground utilities, and piping to treatment systems. In areas with very limited available surface space, LLNL plans to install a single well with multiple screens rather than several wells completed in individual zones. The process for selecting the appropriate well design at each extraction location is shown in Figure 7.

For all extraction wells, LLNL plans to drill and log a pilot borehole and collect sediment samples to determine the local vertical distribution of VOCs. Sediment samples will be collected for sieve analyses to select the appropriate formation stabilizer (sand pack) and well screen slot size. Existing monitor wells will also be used for ground water extraction wherever possible. The existing network of piezometers and monitor wells, as well as planned new piezometers that will fully screen a single water-bearing zone, will be used to monitor the progress of the cleanup. LLNL plans to use a minimum of three piezometers per screened water-bearing zone per extraction location to define hydraulic capture zones and monitor changes in chemical concentrations over time. To mitigate decreases in well efficiency, LLNL plans to periodically monitor drawdown and flow rates and redevelop the wells when necessary. Each RD report will contain additional information regarding the location and specific designs of wells and piezometers for each extraction location, and a detailed well installation schedule for each treatment facility.

3.1.2. Treatment Systems

Based on site analysis and the results of the LLNL pilot studies, seven treatment facilities are planned for the LLNL site, as shown in Figure 3. The seven treatment facility locations (A to G) were selected to minimize the length of piping required to connect the 24 initial extraction locations to the treatment facilities, and to provide efficient discharge routes for treated ground water. The system components for each facility are shown schematically in Figures 8 through 11, and the controls and safeguards for each treatment facility are described in Section 3.1.3. The treatment processes are described in the Feasibility Study (FS), PRAP, and ROD.

If extraction wells produce ground water containing significantly different suites of contaminants, LLNL will treat or pretreat, as appropriate, the different contaminant suites separately. This would maximize treatment efficiency and minimize dilution of contaminant concentrations. However, because the primary goal of the remedial actions is removal of contaminant mass from the subsurface, methods of improving treatment efficiency and minimizing dilution will only be implemented when they are:

- practical,
- cost-effective, and
- do not impair the overall rate of contaminant mass removal.

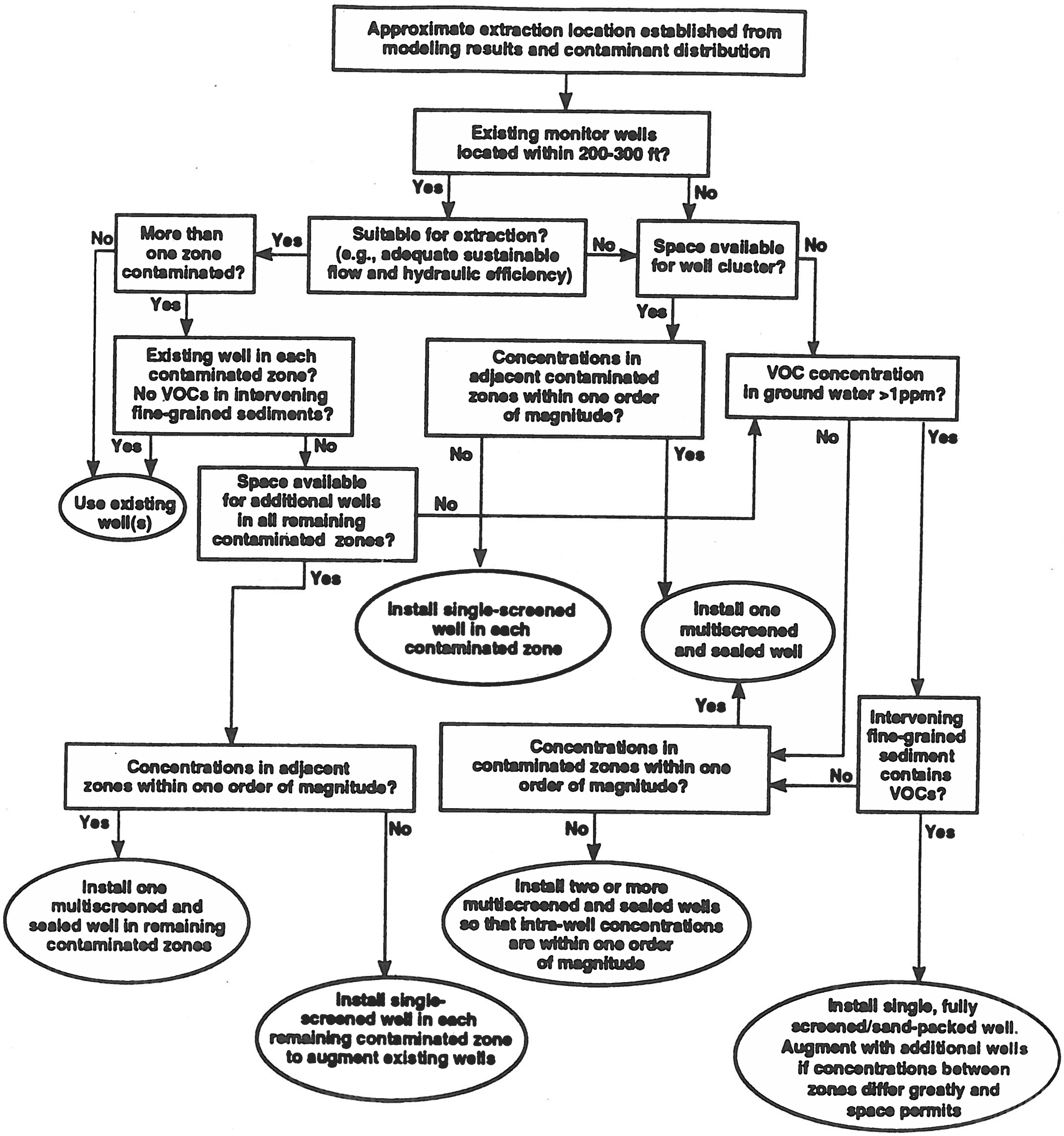

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Figure 7. Extraction well design decisionmaking process.

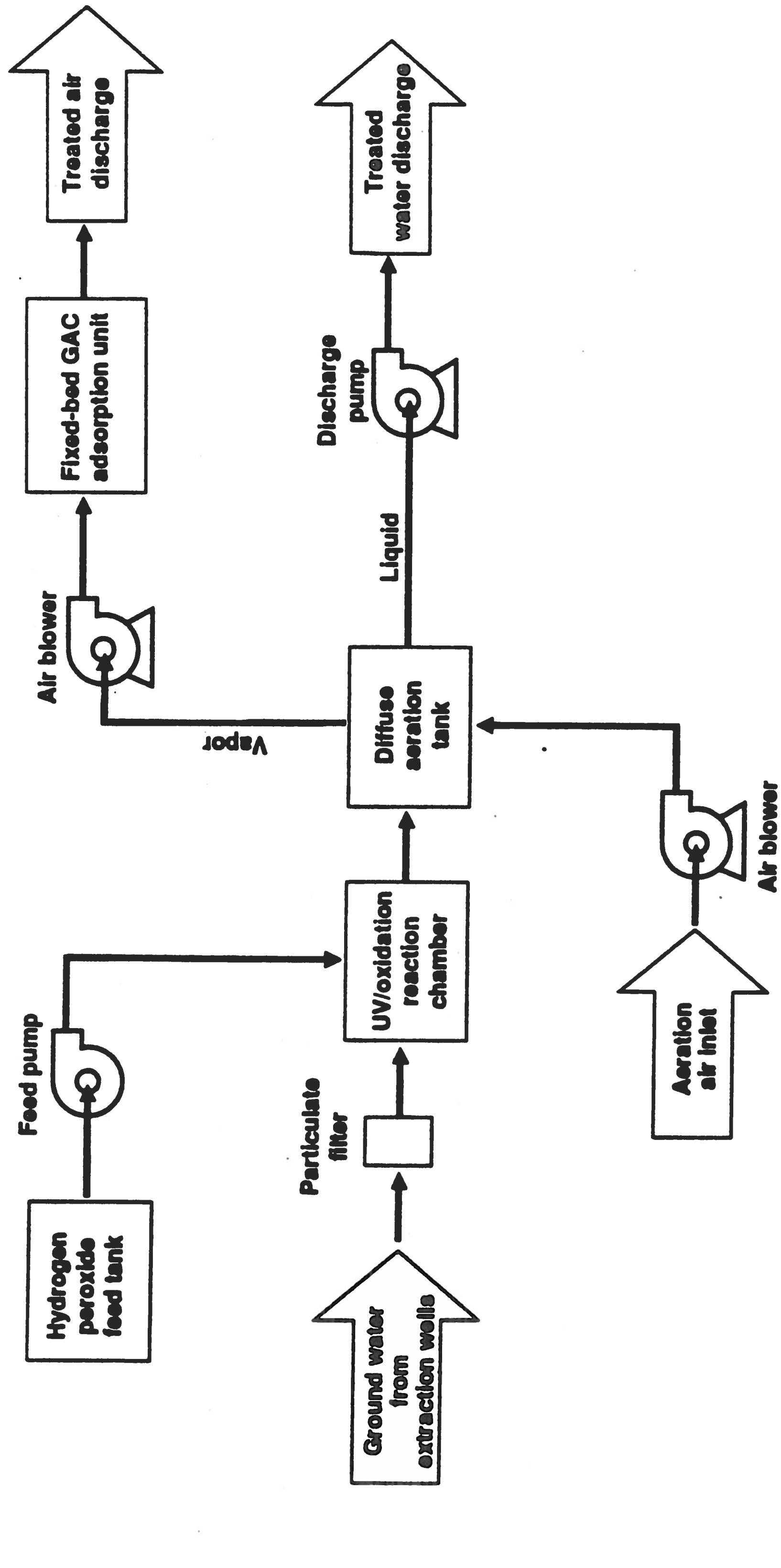

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Figure 8. Schematic diagram of UV/oxidation and air stripping system with GAC vapor treatment for Treatment Facilities A, B, and E.

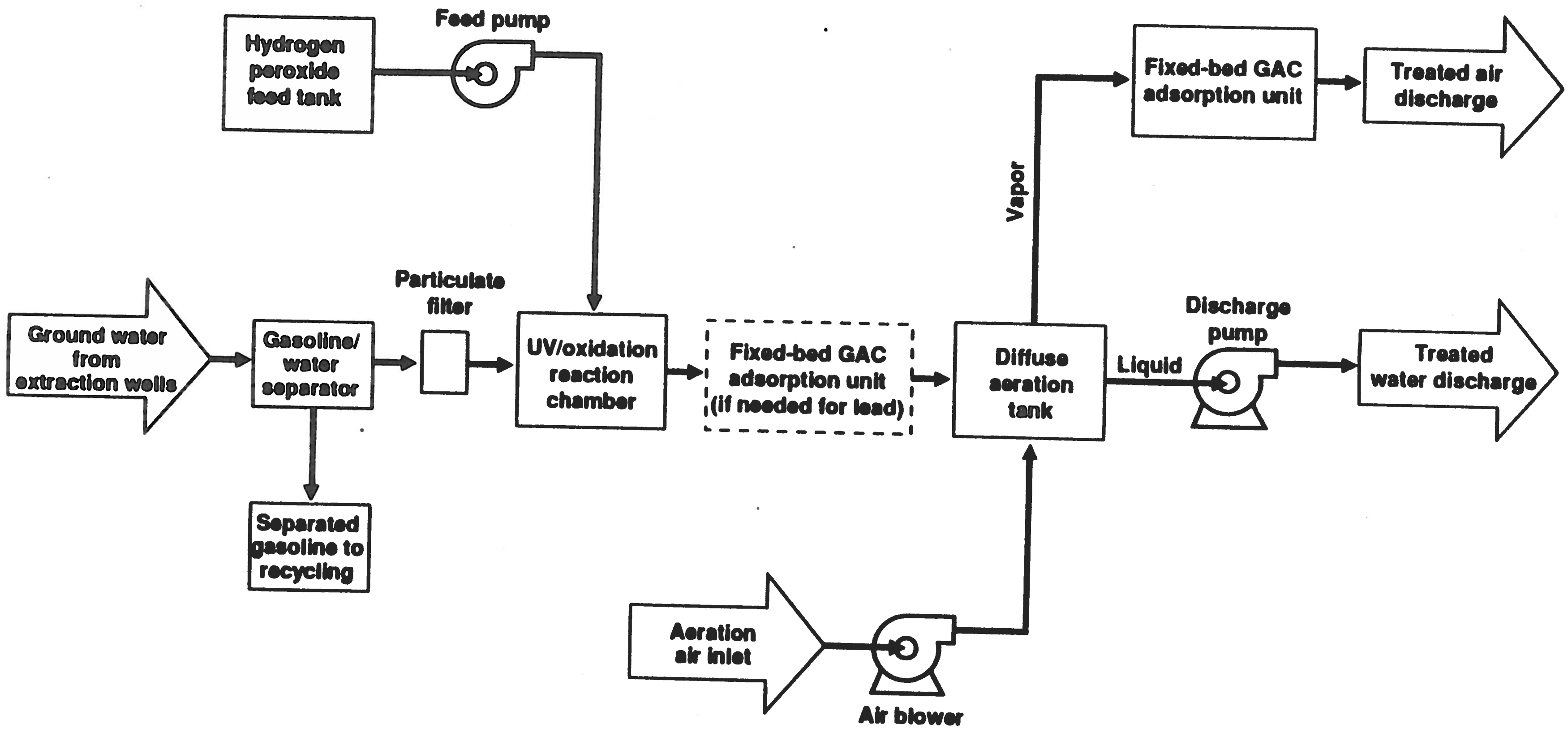

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Figure 9. Schematic diagram of UV/oxidation, water phase GAC for lead removal, if necessary, and air stripping system with GAC vapor treatment for Treatment Facility F.

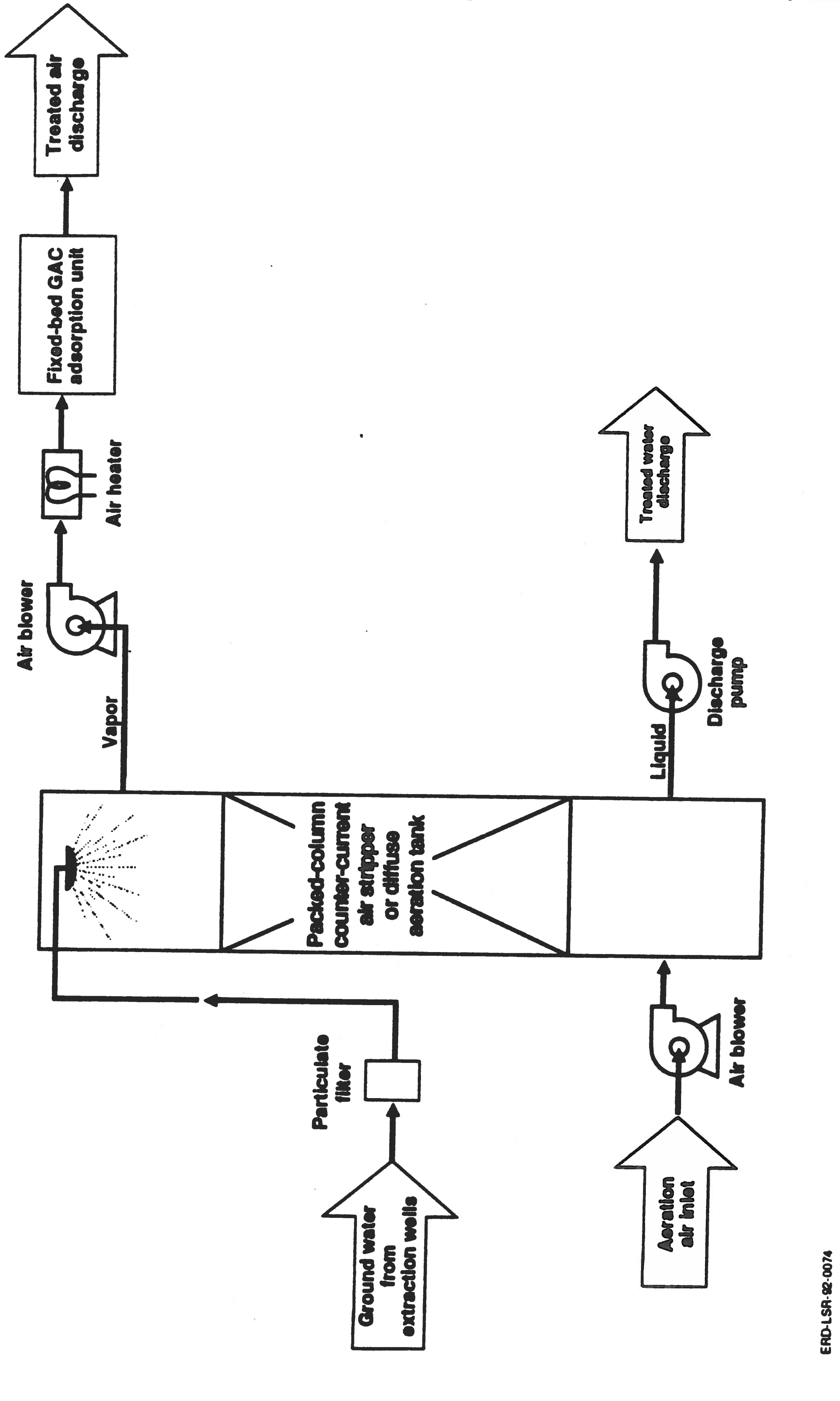

Figure 10. Schematic diagram of air stripper with GAC vapor treatment for Treatment Facility G.

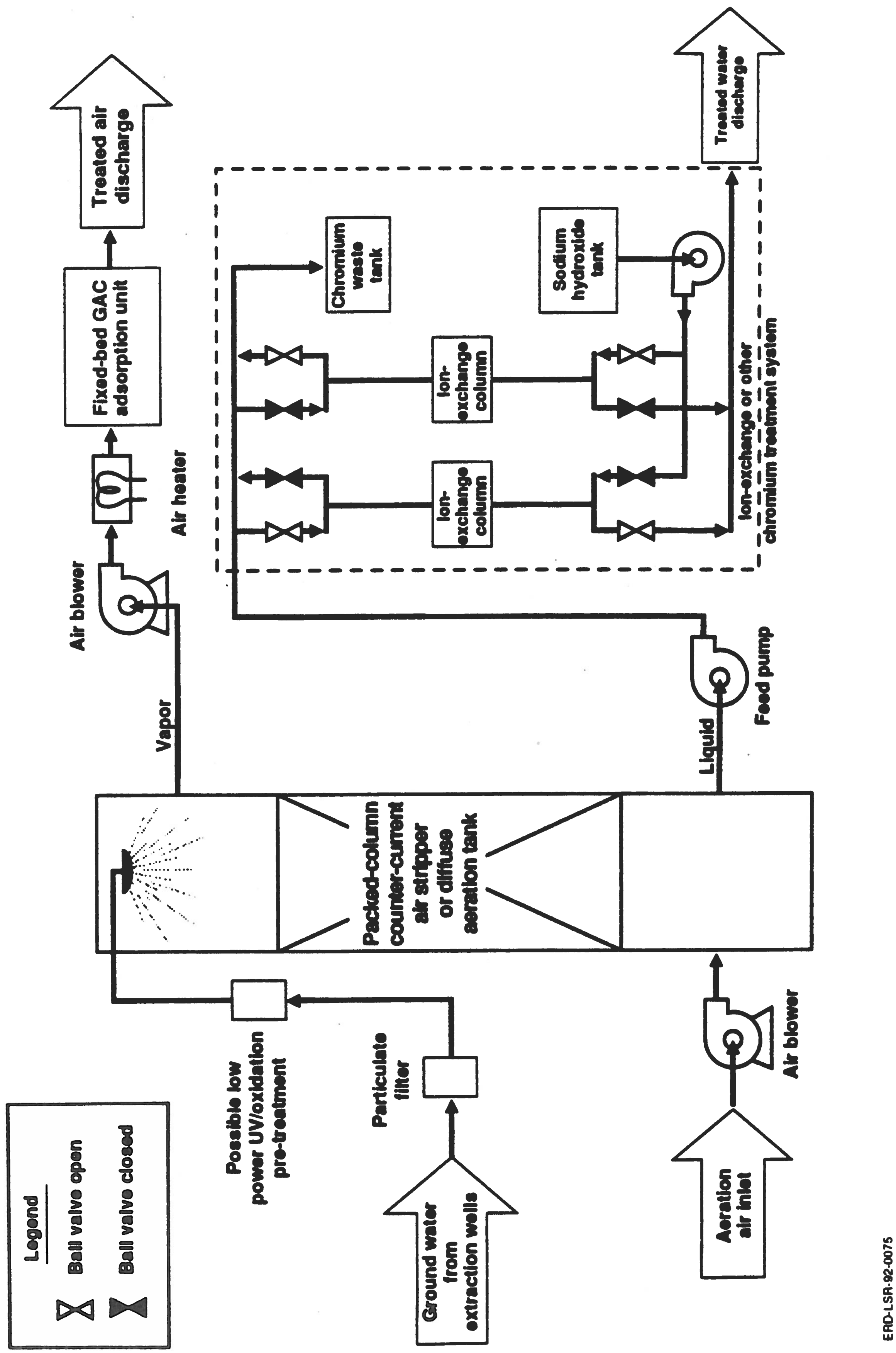

Figure 11. Schematic diagram of air stripper and chromium treatment system with GAC vapor treatment for Treatment Facilities C and D.

Treatment efficiency improvements will be undertaken with regulatory oversight. If new cleanup requirements are promulgated or existing requirements are modified in the future, they will be evaluated at the 5-year reviews specified in the ROD for the LLNL site to determine if:

- achievement of the requirement(s) is applicable or relevant and appropriate, and
- achievement of the requirement(s) is necessary to ensure that the remedy is protective of human health and the environment [40CFR Section 300.430 (f)(1)(ii)(B)].

Each treatment facility will be designed to treat a somewhat different suite of compounds. Treatment Facilities A, B, C, E, and G will treat primarily VOCs. Treatment Facilities C and D (TFC and TFD) will treat chromium as well as VOCs. Treatment Facility F (TFF) will treat VOCs, fuel hydrocarbons (FHCs), and possibly lead. For preliminary design purposes, LLNL has used data from existing monitor wells to estimate the quantity and chemical composition of the ground water influent to each treatment facility. The estimated influent concentrations and flow volumes for the treatment facilities are given in Table 2. The estimated influent flow rate in gallons per minute (gpm) is also shown in parentheses at each treatment facility location in Figure 3. The influent flow rate for each treatment facility is the sum of estimated sustainable pumping rates for each extraction location providing water to the facility.

As described in the FS and PRAP, each treatment facility will be designed to use either ultra-violet light (UV) oxidation or air stripping as the primary process to treat the extracted ground water. Additional technologies, such as diffuse aeration (a form of air stripping), granular activated carbon (GAC), and ion exchange will be used for secondary treatment and/or to remove specific contaminants from the water or air streams. The GAC will be shipped offsite for regeneration. VOCs and metals sorbed to the GAC and ion-exchange resin will be recycled, if possible, or disposed as hazardous waste. All water entering treatment facilities will be filtered prior to entering the treatment system to remove particulates. The VOC concentrations in particulate filters from TFA and TFB have been below the 25 milligrams per liter (mg/L) limit for disposal at a Class III landfill. The filters have also been subjected to a 96-hour fish toxicity test and were shown to be non-hazardous. The filters will therefore be disposed at a commercial Class III landfill.

As described in the ROD, Treatment Facilities A, B, and E will employ UV/oxidation as the primary water treatment technology and a secondary air stripping system, with GAC vapor treatment (Fig. 8). TFF will also use UV/oxidation with secondary air stripping, but with a GAC system for removing lead, if necessary, from the extracted ground water (Fig. 9). The influent water at TFF will flow through a gasoline/water separator before reaching the particulate filter, and the separated gasoline will be sent to a recycling facility. Treatment Facility G will use a packed-column, counter-current air stripper, or a diffuse aeration tank for water treatment, and GAC for vapor treatment (Fig. 10).

TFC and TFD will also employ a packed-column, counter-current, air stripper or a diffuse aeration tank with GAC vapor treatment, and will incorporate an ion-exchange or other system for chromium treatment (Fig. 11). Although ground water in the vicinity of TFC does not

Table 2. Estimated influent concentrations for Treatment Facilities A through G.

Constituents	Concentration (ppb)	
	Maximum influent	Average influent
Treatment Facility A		
Average flow: 150 gpm		
PCE	350	280
TCE	9	7
1,1-DCE	15	12
1,2-DCE (cis and trans)	5	4
1,1,1-TCA	6	5
1,1-DCA	6	5
Chloroform	13	10
Freon 113	6	5
Treatment Facility B		
Average flow: 50 gpm		
PCE	50	40
TCE	375	300
1,1-DCE	13	10
1,2-DCE (cis and trans)	4	3
1,1,1-TCA	1	1
1,1-DCA	6	5
1,2-DCA	1	1
Carbon tetrachloride	3	2
Chloroform	13	10
Freon 113	13	10
Chromium (total)	30	30
Chromium (6^+)	25	20
Treatment Facility C		
Average flow: 20 gpm		
PCE	6	5
TCE	25	20
1,1-DCE	3	2
Chloroform	4	3
Freon 113	125	100
Chromium 6^+	40	30
Treatment Facility D		
Average flow: 70 gpm		
PCE	15	3
TCE	3,000	630
1,1-DCE	34	9
1,2-DCE (cis and trans)	4	1
1,1,1-TCA	2	0.3
1,1-DCA	5	0.5
1,2-DCA	54	8
Carbon tetrachloride	120	23
Chloroform	80	54
Freon 113	2	0.5
Chromium (total)	100	30

Table 2. (Continued)

Constituents	Concentration (ppb)	
	Maximum influent	Average influent
Treatment Facility E		
Average flow: 70 gpm		
PCE	800	430
TCE	4,400	2,900
1,1-DCE	250	160
1,2-DCE (cis and trans)	15	5
1,1,1-TCA	11	6
1,1-DCA	5	4
1,2-DCA	190	68
Carbon tetrachloride	20	7
Chloroform	400	83
Freon 113	80	36
Treatment Facility F		
Average flow: 30 gpm		
PCE[a]	13	10
TCE	250	200
1,1-DCE	13	10
1,1,1-TCA[a]	4	3
1,2-DCA	163	130
Carbon tetrachloride[a]	13	10
Chloroform	25	20
Freon 113[a]	13	10
Benzene	25,000	20,000
Toluene	38,000	30,000
Xylenes	19,000	15,000
Lead	38	30
Treatment Facility G		
Average flow: 40 gpm		
PCE	40	20
TCE	120	53
1,1-DCE	12	3
1,2-DCE (cis and trans)	3	1
1,1,1-TCA	4	1
Carbon tetrachloride	12	7
Chloroform	22	15
Freon 113	10	7

[a]These compounds are present in the Building 518 Area, location number 18 on Figure 3.

contain chromium in concentrations above the 50 ppb MCL, ground water analyses indicate that water influent to TFC may contain hexavalent chromium above the 11 ppb National Pollutant Discharge Elimination System (NPDES) permit discharge limit.

LLNL is considering chemical reduction or ion exchange for treatment of hexavalent chromium in ground water. The chemical reduction method involves converting the hexavalent chromium into the trivalent form, which is considered less hazardous and has a higher discharge limit (0.011 vs. 0.050 mg/L, respectively). Three reducing agents are being evaluated for use with LLNL ground water: ferrous sulfate, hydrogen peroxide, and sodium meta-bisulfite. If discharge limits cannot be met by chemical reduction alone, then precipitation and chromium removal will follow the reduction.

The ion-exchange method uses a polymer resin in which anions attached to the polymer are exchanged with the hexavalent chromium in solution. A typical anion used in this process is chloride. Resin regeneration will be conducted onsite or by the resin vendor. Three different resins are being tested with LLNL ground water. Although initial tests indicate the hexavalent chromium removal is satisfactory, the effectiveness of various resins is being investigated over a range of conditions.

3.1.3. Treatment System Controls and Safeguards

All treatment facilities will be equipped with an interlock control system. If any portion of the system malfunctions, the entire system, including the associated extraction wells, automatically shuts down until the problem is determined and corrected.

Centrifugal extraction pumps have thermal shut-off devices installed to prevent overheating due to insufficient water levels in the wells. All treatment systems employing UV/oxidation will have a pressure sensor on the hydrogen peroxide feed line that will shut the system down if the hydrogen peroxide system pressure is too low. Other systems will also shut the facility down if:

- An ultraviolet lamp fails.
- Excessive temperature in the reaction chamber is detected.
- Excessive moisture accumulates in the ultraviolet lamps.

Treatment systems employing air stripping will have:

- Influent and effluent blower controls.
- A high water level sensor in aeration tanks.
- A supply air pressure control that will shut the system down in the event of a pipe break.
- A supply and exhaust pressure interlock that prevents operation of the system if blowers are off-line.

Facilities requiring chromium treatment, including the feed pump to the chromium treatment system, will be shut down when the pH exceeds discharge limits ($6.5 < pH < 8.5$) or if a critical component of the chromium treatment system fails.

During normal working hours, each operating treatment facility is frequently checked by the facility operator. In the event of a shutdown, the facility control system will register the type of shutdown that occurred such that the operator can trace and correct the problem. In the event of a shutdown during off-shift hours and/or over the weekend, the facility will remain shutdown until the start of the following workday.

3.1.4. Sampling Schedules and Plans

The types of samples and analyses, and the sampling frequencies for each treatment facility, will be specified in the RA Workplan for each RD Report. According to current RWQCB guidelines, a ground water sample will be collected at a sampling station immediately prior to treatment and at a station immediately following treatment. Discharge of treated water is continuous unless the water is being used for landscape irrigation. If used for irrigation, the treated water is temporarily stored in 20,000-gallon tanks near the treatment facility. For those treatment systems that will discharge water to a ditch or arroyo, RWQCB requirements for TFA and TFB indicate that effluent samples will be collected prior to discharge to surface waters or drainage ways. In addition, an effluent sample will also be collected at a station between 50 and 100 feet downstream from the effluent discharge point.

A hand-held monitoring device, such as a photo-ionization detector or flame ionization detector, will be used to determine if any residual contaminants remain in the air effluent stream from treatment facilities employing air stripping. The detection limits for these instruments are sufficiently low to ensure compliance with air discharge limits.

3.2. Vadose Zone

LLNL's current understanding of the distribution of vadose zone contaminants at LLNL, their potential for migration to ground water, and the locations of vadose zone source areas that require remediation is based on the LLNL RI (Thorpe *et al.*, 1990), the LLNL FS (Isherwood *et al.*, 1990), ongoing source investigations, and the LLNL Vadose Zone Investigation Program (Macdonald *et al.*, 1991b).

As discussed in Section 2.2 of this report and in the ROD, modeling will be used to determine whether vadose zone contaminants require remediation. Modeling will be used to evaluate the potential for vadose zone contaminants to impact the underlying ground water in concentrations above an MCL. If such a potential exists, vadose zone remediation will be conducted. Sections 3.2.1.1 through 3.2.1.3 and Sections 3.2.2.1 through 3.2.2.5 present remediation plans for the three known areas at LLNL where vadose zone remediation will be required. Other areas may be added pending the results of ongoing source and vadose zone investigations.

As discussed in the ROD, FHCs in the Gasoline Spill Area, VOCs in the Building 518 Area, and VOCs in the East Taxi Strip–Trailer 5475 Area (Fig. 12) will require vadose zone remediation. Results of recent source investigations in the East Taxi Strip–Trailer 5475 Area indicate that VOC concentrations up to about 23 parts per million (ppm) exist in the vadose zone just above water table, probably in the capillary fringe. VOC concentrations between 1 and 7 ppm in a larger area from 30-foot depth to the water table, which occurs between depths of 87 to

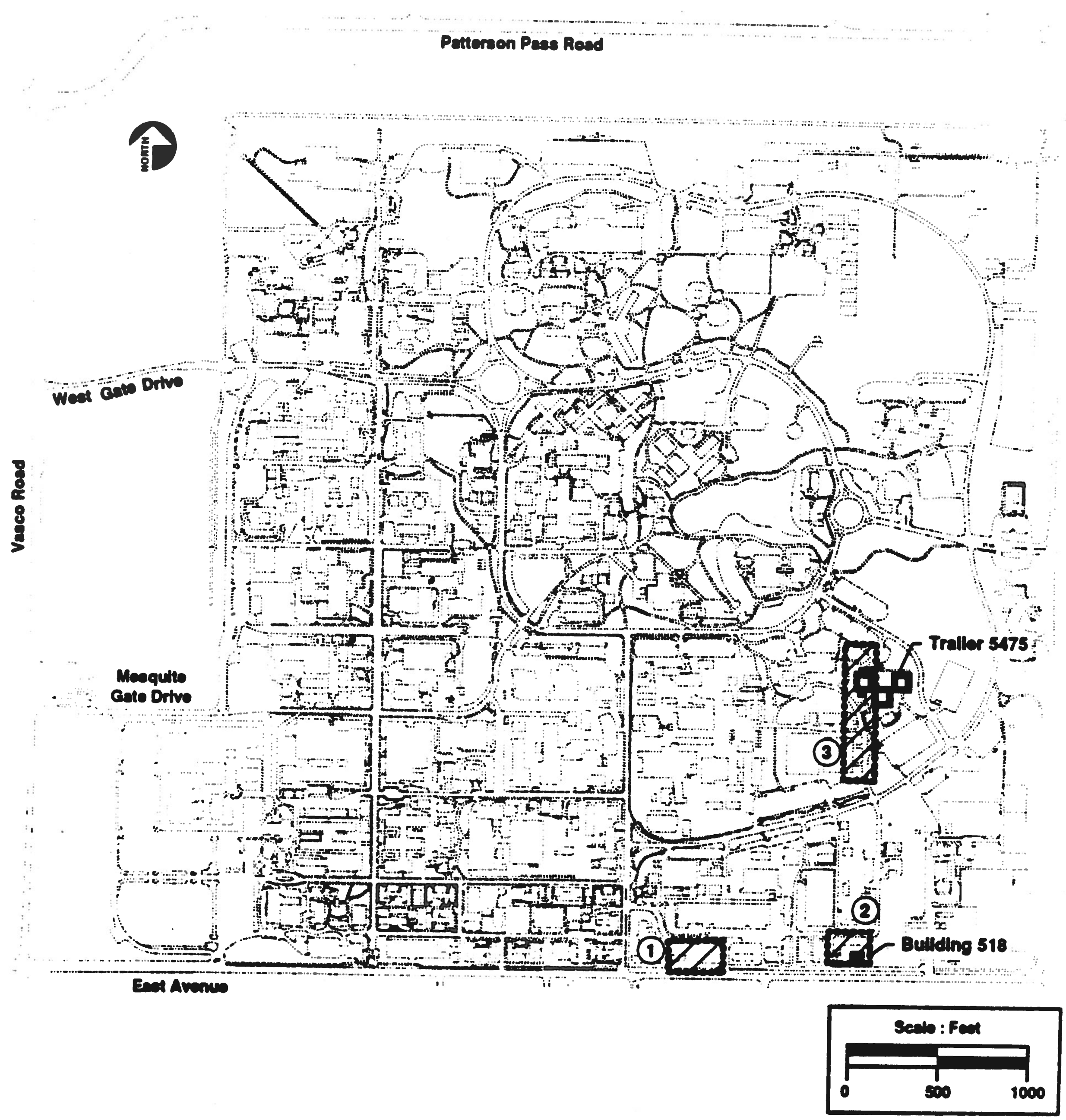

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Figure 12. Vadose zone VOC remediation sites at LLNL: (1) Gasoline Spill Area, (2) Building 518 Area, and (3) East Taxi Strip-Trailer 5475 Area.

95 feet in this area. These recent data collected subsequent to the ROD indicate that vadoze zone VOCs in the East Taxi Strip–Trailer 5475 Area will require remediation.

Tritium in the vadose zone at LLNL is elevated above background levels in the Building 514, Eastern Landing Mat Storage, West Traffic Circle, Building 292, and Old Salvage Yard Areas. LLNL plans to minimize tritium transport in the LLNL subsurface and allow the tritium to decay naturally such that it will not adversely impact beneficial uses of ground water. In the unsaturated zone, this may be accomplished by installing a low-permeability surficial cap, where appropriate, to minimize infiltration of surface water. In the saturated zone, tritium migration will be mitigated by establishing hydraulic control of the ground water containing tritium. This will be accomplished by (1) controlling extraction well flow rates and/or (2) re-injecting treated water downgradient of wells containing tritium to create a hydraulic barrier.

As described in the ROD, vacuum-induced venting to extract FHC and VOC vapors from the vadose zone, followed by GAC treatment at the surface, is the selected vadose zone remediation for the LLNL site. The technical feasibility and cost-effectiveness of new vadose zone remediation technologies (e.g., heating fine-grained sediments) will be evaluated to increase the efficiency of vadose zone remediation, particularly for low-permeability sediments.

The planned locations and preliminary designs of vadose zone extraction wells at the Gasoline Spill, Building 518, and East Taxi Strip–Trailer 5475 Area are presented below in Sections 3.2.1.1. through 3.2.1.3. Surface treatment of the extracted vapor is described in Section 3.2.2.

3.2.1. Vadose Zone Extraction Wells

The effectiveness of *in situ* soil vapor extraction as a remediation strategy is dependent on three main factors (Johnson *et al.*, 1990):

- Physical and chemical characteristics of the contaminants.
- Vapor flow rates through the vadose zone.
- The relationship of vapor flow paths and the distribution of contaminated soil.

For each vadose zone remediation area, LLNL plans to:

1. Drill a pilot borehole at the center of the estimated contaminant mass and collect samples for lithological and chemical analyses.
2. Design and construct a soil vapor extraction well in the pilot borehole based on the results of No. 1.
3. Install approximately three to four vadose zone monitor wells in a radial pattern at various distances from the extraction well. These vadose zone monitor wells will be instrumented to collect air pressure and soil gas chemistry data from multiple depths.
4. Conduct air permeability field tests at each soil vapor extraction well and monitor vapor flow rates, soil gas pressure, and chemical changes in the vadose zone monitor wells. The design of these tests will depend on the distribution of contaminants and lithology encountered in the pilot borehole.

5. Utilize the empirical field results and quantitative modeling of the vapor extraction process to evaluate the effectiveness and capture area of the extraction well.

6. Based on the observed zone of influence and the distribution of contaminants, design and construct additional vacuum-induced venting wells, as needed, to remediate the site.

7. Evaluate the effectiveness of remediation by analyzing soil and soil gas samples and conduct quantitative modeling to evaluate whether residual VOCs would impact in ground water in concentrations above drinking water standards.

8. Modify and/or enhance the remediation system, if necessary, to complete remediation.

Vacuum-induced venting pilot studies were conducted at the Gasoline Spill Area using test venting well GSW-16, which is multiply-screened in fine-grained (low permeability) sediments with high FHC concentrations (Isherwood *et al.*, 1990). Vapor extraction test results indicate that this venting well design was effective in removing subsurface contaminants, but after 2.3 years of discontinuous operation, residual contamination still persists in the fine-grained sediments (Oberdorfer and Cook, 1992). These data suggest that vapor capture areas were limited and that considerable venting may be required to remediate the fine-grained sediments.

In future venting wells, LLNL plans to target zones of high VOC concentrations. A single venting well may be initially installed with multiple screens and intervening grout seals to isolate specific target intervals, or multiple single-screen venting wells may be initially installed. The screened intervals will probably be installed adjacent to predominantly moderate- to high-permeability sediments. The specific well design will depend on the VOC distribution, lithology and inferred permeability, cost, and the estimated time to achieve remediation, as determined by quantitative modeling.

In the multiply-screened well design, packers will be used to isolate the screened interval(s) and allow selective vapor extraction from specific depth intervals. In multiple wells with single screened intervals, manipulation of the applied vacuum at each well will provide selective control of subsurface vapor extraction. These designs should greatly increase the venting well's capture zone over that observed in GSW-16, and consequently, maximize the air mass flow rate through the subsurface, increase VOC vapor diffusion from fine-grained sediments, and maximize the VOC mass removal rate.

If contaminated low-permeability sediments are not effectively remediated as determined by soil vapor samples from the silts and clays, other technologies such as electrical resistance heating of the fine sediments will be considered. A generalized soil vapor extraction well design is presented in Figure 13.

If significant contaminant concentrations occur in saturated sediments below the water table, such as the Gasoline Spill Area, dewatering and venting of these sediments may be employed to expedite remediation. The vertical distribution of chemicals in the vadose zone and physical properties of the sediment, such as hydraulic conductivity, will be assessed in each area to determine whether simultaneous ground water extraction and venting are required for effective remediation. If coupled soil vapor and ground water extraction are required to effectively remediate a source area, the soil vapor extraction well design will be modified to include one or

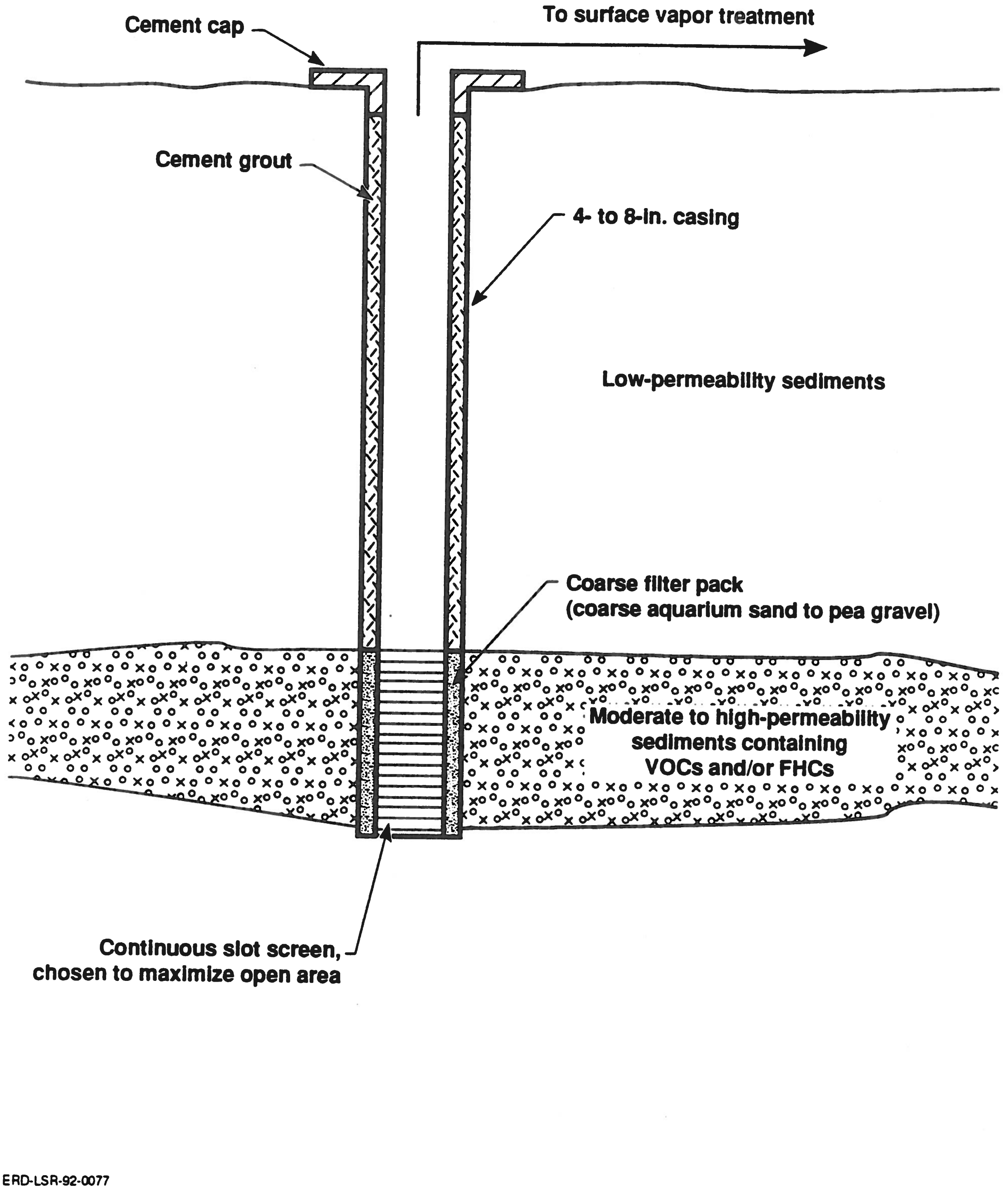


Figure 13. Generalized soil vapor extraction well design.

more screened interval(s) below the water table, or separate ground water extraction wells will be installed.

Surface seals (such as asphalt paving), passive air-inlet wells (wells completed in the vadose zone that are open to the atmosphere), and air injection wells, which may also be used for soil moisture management, may be required to manipulate vapor flow pathways during vacuum extraction (Johnson *et al.*, 1990). The need for these will be evaluated on a site-specific basis. Remediation effectiveness will be evaluated by the soil gas chemical data collected from the vadose zone monitoring wells, quantitative modeling, and soil sampling. The planned vadose zone extraction well locations and designs for the Gasoline Spill, Building 518, and East Taxi Strip–Trailer 5475 Areas are described below.

3.2.1.1. Gasoline Spill Area

An EPA-approved pilot study of vacuum-induced venting in heterogeneous sediments has been conducted in the Gasoline Spill Area (Fig. 12). For 179 days over a 2.3-year period, vacuum-induced venting removed the liquid-equivalent of approximately 1,980 gallons of gasoline, which was treated at the surface by thermal oxidation (Macdonald *et al.*, 1991a).

LLNL is conducting a demonstration project funded by DOE to evaluate whether subsurface steam flooding coupled with electrical heating of fine-grained sediments can quickly clean up the highest FHC concentrations in the LLNL Gasoline Spill Area (Aines *et al.*, 1992). This project, called the Dynamic Underground Stripping Demonstration Project, has consisted primarily of detailed characterization of the Gasoline Spill Area and conducting a steam injection test at an uncontaminated site (the Clean Site) located south of LLNL on DOE property administered by Sandia National Laboratories. The current schedule calls for beginning electrical heating and steam injection at the Gasoline Spill Area in late 1992 and early 1993, respectively.

Treatment Facility F will treat ground water extracted during the demonstration project. An air-cooled heat exchanger will lower the ground water temperature prior to the oil/water separators. A turbidity meter will continuously monitor the liquid stream exiting the separators, and the facility will shut down if free product is detected in the liquid stream. A water-cooled heat exchanger will lower the temperature of extracted vapor prior to demisting and treatment with GAC. Condensed liquid will be treated by the ground water treatment system. The ground water heat exchanger, vapor heat exchanger, demister, and carbon for extracted soil vapor are part of the demonstration project and will not be included in the permanent design, which will be detailed in RD Report No. 2.

After the demonstration project is complete, ground water and vapor extraction, with surface treatment of the ground water and vapor, and/or enhanced bioremediation, will be conducted to complete the remediation of the Gasoline Spill Area. Laboratory tests on cores from the Gasoline Spill Area have isolated spore-forming bacteria that are capable of biodegrading gasoline and surviving at the elevated temperature imposed by steam injection. Repopulation of native bacterial species or introduction of nonindigenous species may be necessary following steam flooding if enhanced bioremediation is conducted.

Although removal of free-phase gasoline at and below the water table is the primary objective of this demonstration project, the lower portion of the vadose zone is also expected to be at least partially remediated in the process.

Chemical data from boreholes will be evaluated to determine the remaining distribution of FHCs in the vadose zone after dynamic stripping is complete. These data will be used to determine the need for and type of further vadose zone remediation required at this site. At present, it appears that either vacuum-induced venting or bioremediation of the vadose zone will be employed to remove residual FHCs. Extracted vapors will be treated by GAC. In the future, a catalytic oxidation treatability study, and perhaps a startup test, may be conducted as described in Sections 4.2.1.2 and 4.2.1.3.

Available data indicate that a screened interval of 15 to 60 feet below ground surface may be appropriate for the initial vadose zone extraction well in the Gasoline Spill Area.

3.2.1.2. Building 518 Area

The planned location for the initial vacuum-induced extraction well in the Building 518 Area is shown in Figure 14. The planned extraction well is located near the highest VOC concentrations detected in soil samples from boreholes. Modeling of VOC migration from the vadose zone to the ground water (Isherwood *et al.*, 1990) indicate that the VOCs in the vadose zone in this area could impact the ground water in concentrations above MCLs. The localized area with total VOC concentrations exceeding 1 ppm north of Building 518 on Figure 14 does not require remediation because it is very localized, less than 5 feet deep, and quantitative modeling results for a similar VOC distribution in the nearby Building 511 Area (see Appendix G of the LLNL FS) indicate such a distribution poses no threat to ground water. Existing soil VOC data indicate that screened intervals of 8 to 50 feet and 84 to 92 feet below the surface may be appropriate for the initial vacuum-induced venting well at Building 518.

3.2.1.3. East Taxi Strip–Trailer 5475 Area

Preliminary results from the ongoing source investigation activities at the East Taxi Strip–Trailer 5475 Area (Fig. 12) indicate that VOCs in the vadose zone in this area will require remediation. The results of source investigation activities in this area will be published in a forthcoming *LLNL Ground Water Project Monthly Progress Report.*

The preliminary location for the initial vacuum-induced venting extraction well in the East Taxi Strip–Trailer 5475 Area, shown in Figure 15, is near a former disposal pit, which is believed to be the source of VOCs in the underlying ground water. The 23-ppm concentration shown in Figure 15 is predominantly 1,1,1-TCA, which is not present in the underlying ground water in concentrations above its MCL. The location of this initial well may be changed pending additional planned subsurface investigations. The relatively large extent of vadose zone VOC concentrations exceeding 1 ppm in this area suggests that more than one vacuum-induced venting well will be required. The need for additional wells will be evaluated on the basis of the

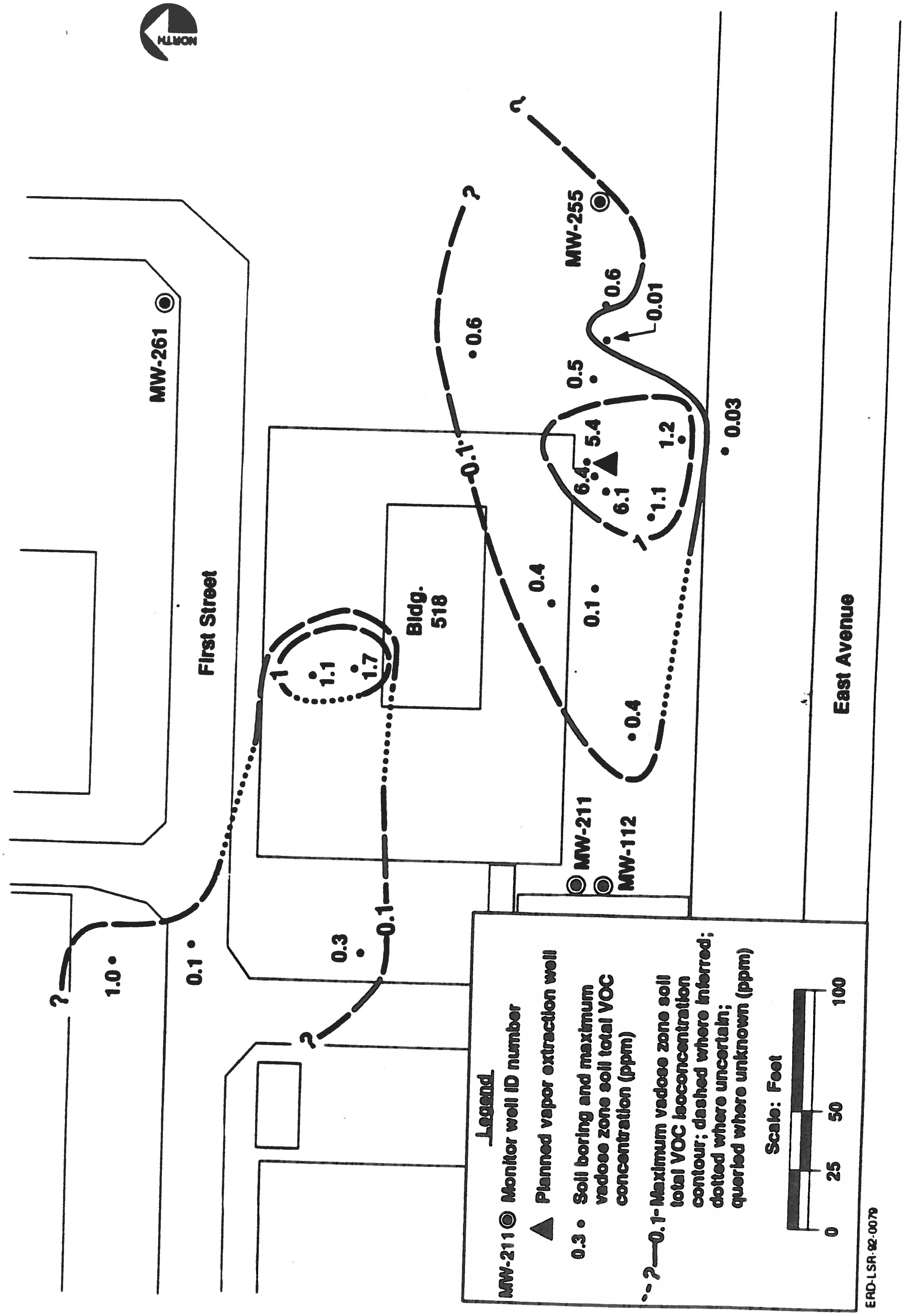


Figure 14. Planned initial vadose zone extraction well location, Building 518 Area.

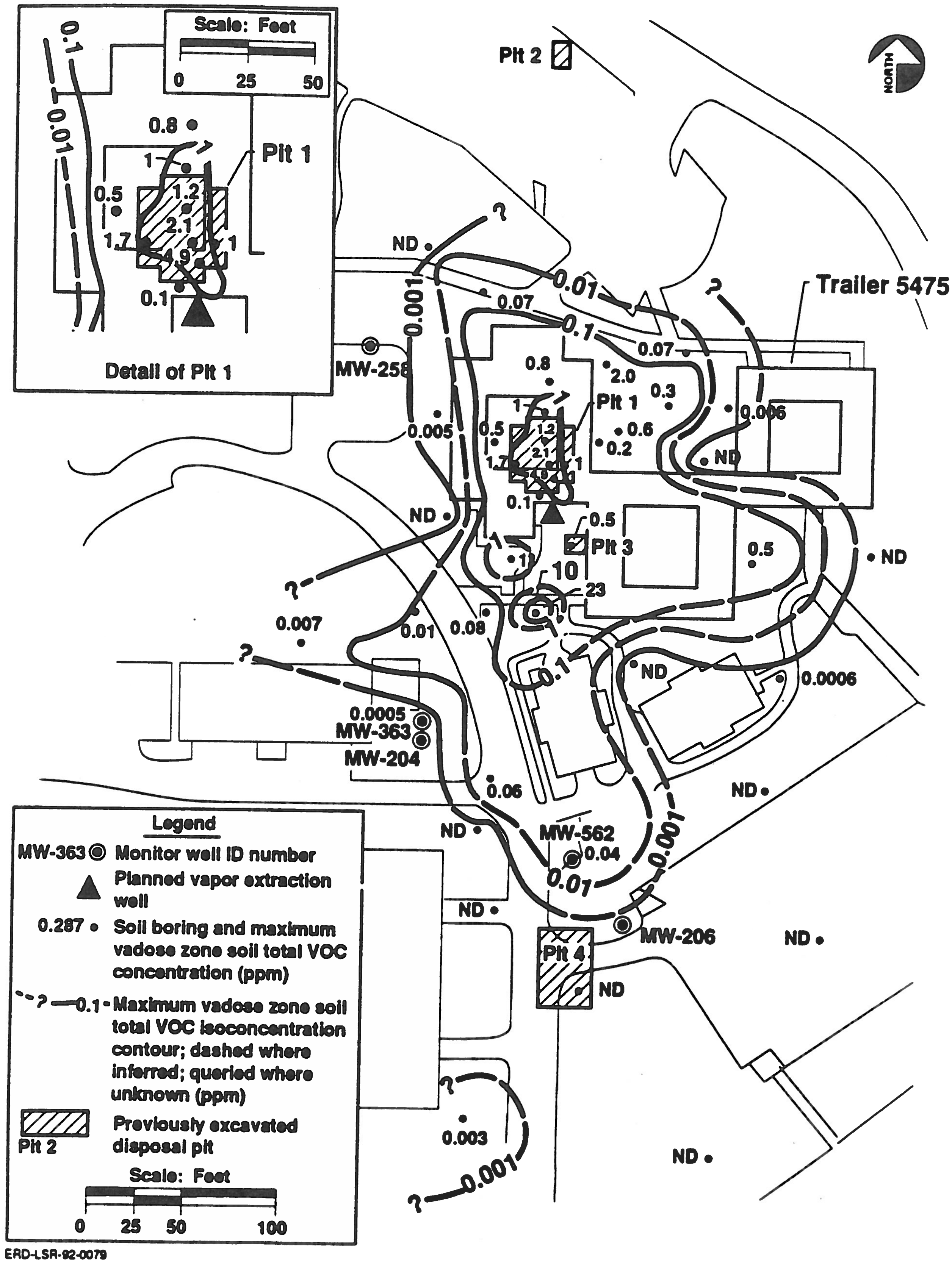


Figure 15. Preliminary vadose zone extraction well location, East Taxi Strip/Trailer 5475 Area.

initial vadose zone air permeability tests, described previously in Section 3.2.1, the distribution of VOCs in the vadose zone, and the performance of the initial extraction well.

3.2.2. Treatment Systems

As discussed in the preceding section, volatile compounds will be withdrawn from the vadose zone in the Gasoline Spill, Building 518, and East Taxi Strip–Trailer 5475 Areas by vacuum-induced venting. VOC vapors will be conveyed from the Building 518 Area to TFF for treatment with the FHCs and VOCs from the Gasoline Spill Area. VOC vapors from the East Taxi Strip–Trailer 5475 Area may be treated at a new facility in that area, or perhaps at TFE depending on logistics and piping costs.

LLNL is planning to use GAC for treatment of VOC and FHC vapor at TFF instead of the catalytic oxidation process discussed in the ROD. This change is necessary because recently available onsite GAC regeneration capabilities, and the costs of the catalytic oxidation treatability and startup tests, now make GAC more cost-effective. In addition, a recent assessment indicated that LLNL does not have the necessary staff to conduct the catalytic oxidation treatability study and startup tests before the March 1993 start-of-operation date for TFF (see Section 5). The reasons for making the change to GAC from catalytic oxidation will be detailed in a regulatory document provided for in the National Contingency Plan called an Explanation of Significant Differences. The GAC system for treating the vapor will be described in Draft RD Report No. 2 (see Section 5). LLNL may still conduct a catalytic oxidation treatability study in the future, and perhaps a full-scale startup test, if funding and resources allow.

3.3. Discharge of Treated Ground Water

Three methods are planned for the discharge of treated ground water from LLNL treatment facilities:

- Discharge to the ground surface, including the LLNL recharge basin and the Arroyo Las Positas drainage ditches.
- Reinjection into the uppermost water-bearing zones. It is anticipated that the injection zones will be within 30 to 50 feet of the water table. Water recharged via wells will be located within the hydraulic capture area of an extraction well, as determined by field monitoring of water levels.
- Onsite use for landscape irrigation and in LLNL cooling towers.

These three planned discharge methods are described further in Sections 3.3.1. through 3.3.3.

3.3.1. Discharge to the Ground Surface

Treated ground water will be discharged to the ground surface via the LLNL recharge basin and the Arroyo Las Positas drainage ditch system, as discussed below. No discharges to the ground surface will occur in areas containing elevated tritium concentrations in the vadose zone.

3.3.1.1. Recharge Basin

Figure 3 shows that the LLNL recharge basin is located about 1,000 feet south of East Avenue. The basin consists of two rectangular cells, each covering an area about 550 by 100 feet. Two adjacent recharge cells were constructed to allow periodic maintenance of the inactive cell. The entire basin is bermed to prevent accidental surface runoff.

A hydraulic testing program for the sediments underlying the recharge basin, conducted in July 1988, consisted of five laboratory permeameter tests, six borehole tests, one infiltrometer test, six pit percolation tests, and three whole-trench tests. The results of the program indicate the infiltration capacity of the sediments is about 1.9 feet per day (Dresen *et al.*, 1988). Employing a safety factor of approximately 5, the recharge basin cells were designed using an infiltration rate of 0.4 feet per day and an influent flow rate of 100 gpm.

Ground water processed at TFA can be discharged to either of the recharge basin cells via an existing underground pipeline. Water discharged to the basin percolates through the underlying unsaturated sediments and eventually recharges the local ground water system. About 21 million gallons of ground water processed at TFA have been discharged to the basin since March 1989 under RWQCB Waste Discharge Requirement (WDR) Order No. 88-075. Available data indicate that over 90% of the water discharged to the recharge basin to date has infiltrated into the ground.

LLNL is also investigating the possibility of discharging ground water processed at TFF and TFG to the recharge basin.

3.3.1.2. Arroyo Las Positas Drainage Ditches

Ground water processed at TFB during pilot studies has been discharged to an unlined north-flowing drainage ditch located along the eastern side of Vasco Road. About 3,500 feet from the discharge point, the ditch flows into Arroyo Las Positas, which flows northwest from LLNL (Fig. 3). TFB pilot study self-monitoring land observations indicate the majority of treated water discharged to this ditch infiltrates into the underlying sediments before reaching Arroyo Las Positas. Over 1.4 million gallons of ground water processed at TFB have been discharged to the Vasco Road ditch since September 1990 under RWQCB NPDES Permit No. CA0029289, WDR Order No. 91-091.

Ground water treated at planned TFC will be discharged to a north-flowing unlined drainage ditch located in the northwest corner of LLNL (Fig. 3). The TFC drainage ditch, and the drainage retention basin overflow drainage ditch located in the eastern part of the LLNL site, eventually flow into Arroyo Las Positas (Fig. 3). Ground water processed at planned facilities TFD and TFE will be discharged to the drainage retention basin, located near the LLNL East Traffic Circle (Fig. 3). This basin was recently lined to prevent infiltration of water that would adversely affect hydraulic capture areas in this area when ground water extraction begins.

3.3.2. Recharge Wells

Ground water flow modeling indicates that reinjection of treated ground water into the uppermost water-bearing zones (i.e., between about 100 and 175 feet in depth) south of southeastern LLNL (Fig. 3) may help limit the amount of dewatering due to pumping in the southeast corner of LLNL. Treated water for reinjection in this area would likely come from TFF. The southeast part of the study area is more susceptible to dewatering due to lower transmissivity of the sediments and the lack of natural ground water recharge (Thorpe *et al.*, 1990). By prohibiting excessive dewatering, extraction wells should be capable of maintaining higher sustained yields, thus decreasing cleanup time. In addition, subsurface recharge may decrease cleanup time by flushing clean water through sediments containing adsorbed VOCs.

Ground water will be recharged in the southeast part of the study area using former steam extraction well EW-SNL-707, located south of southeastern LLNL on property administered by Sandia National Laboratories (Fig. 16). EW-SNL-707 is continuously screened and sand-packed from 98 to 175 feet over four water-bearing zones. All four of these zones are free of VOCs and are located near the southern margin of a TCE-dominated plume that originates at the LLNL site to the north. Because VOCs are present within about 300 feet of EW-SNL-707, reinjection should help to hydraulically contain this plume.

Figure 16 shows the predicted hydraulic capture zones for the 18 extraction locations shown in the ROD for the LLNL site. As seen in Figure 16, well EW-SNL-707 is within the predicted capture zones for extraction locations in the southern part of LLNL. Hydraulic capture of the water recharged at EW-SNL-707 will be verified by field monitoring of water levels. If field monitoring indicates the water is not being captured, LLNL will increase the pumping rates and/or install additional wells to hydraulically capture the recharged water.

EW-SNL-707 was formerly used in the Dynamic Underground Stripping Clean Site Demonstration Project as an extraction well (Aines *et al.*, 1992). The steam process has apparently increased the hydraulic efficiency of this well by removing fines and/or causing geochemical changes which may have dissolved intergranular cement in the screened sediments. This hydraulic enhancement should facilitate the conversion of EW-SNL-707 to an effective ground water recharge well. EW-SNL-707 currently produces in excess of 60 gpm. LLNL anticipates injecting about 20 gpm of treated ground water into this well.

LLNL is also considering discharging water from TFF to an infiltration trench, which may be constructed in the southeast corner of LLNL, just west of and parallel to Greenville Road. This area is upgradient of any known VOCs in ground water, but may dewater in response to planned nearby ground water extraction. A recharge well is not feasible for this area because low-permeability silt and clay predominate the local saturated sediments.

A hydraulic testing program was conducted on the shallow sediments in the southeast corner of LLNL that included five test pits and three boreholes drilled to the water table. The results of this program indicate the infiltration capacity of the sediments is about 0.66 feet per day. Employing a safety factor of 3, a trench 1,500 feet long, 2.5 feet wide, and 10.5 feet deep would be capable of recharging up to about 35 gpm of treated ground water. An overflow channel would convey any excess water to the drainage retention basin via an unlined drainage ditch (Dresen *et al.*, 1991). The drainage ditch would be lined in the vicinity of the East Traffic Circle to prevent infiltration of water into shallow sediments that contain high concentrations of VOCs.

LLNL also plans to recharge ground water processed at TFE to upper water-bearing zone sediments in the central portion of LLNL (Fig. 16), where total VOC concentrations are less

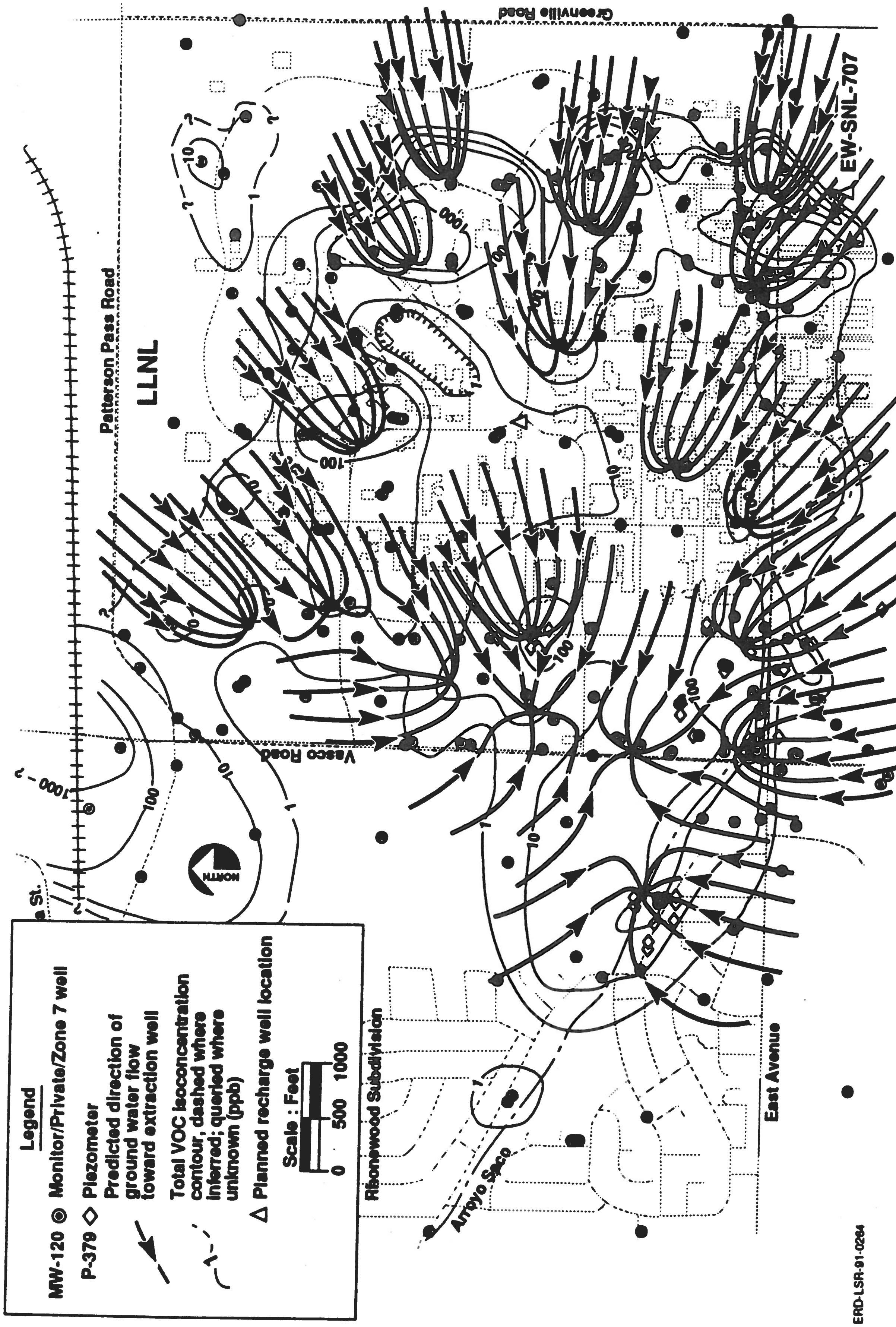


Figure 16. Extraction well hydraulic capture zones and recharge well locations (modified from the Record of Decision for the LLNL Site).

than 1 ppb. Modeling indicates that injecting water into the upper water-bearing zones in this area will provide a source of recharge for planned ground water extraction wells in the southwest area of LLNL. Because LLNL plans to install several ground water extraction wells upgradient of the southwest area, the natural ground water flux to the southwest corner will be diminished. By recharging the treated ground water upgradient of the southwest area extraction wells, dewatering of the upper water-bearing zones that currently contain higher concentrations of VOCs should be mitigated. In addition, injecting water into the upper water-bearing zones in the central portion of LLNL should inhibit further migration of VOCs from the areas of higher VOC concentration in eastern LLNL by creating a local hydraulic barrier.

A fully screened and sand-packed recharge well screened from the top of the water table to a depth of about 200 feet is planned for the central portion of the site (Fig. 16). Figure 17 shows the general design of this well. Data from nearby monitoring wells indicate that this well should be capable of recharging up to 50 gpm. Recharge of treated ground water via wells is covered under NPDES Permit No. CA0029289 for the LLNL site.

The designs of specific recharge wells will be described in the appropriate RD report.

3.3.3. Onsite Use

To reduce the amount of imported water LLNL uses in onsite cooling towers and for onsite landscape irrigation, treated ground water processed at treatment facilities will be used for these purposes. LLNL has used about 23 million gallons of ground water treated at TFA and TFB in cooling towers and for landscape irrigation since September 1990. Recent modeling results indicate that up to about one-third of the total estimated extracted water, about 100 gpm, may be available for such onsite uses, with the other two-thirds used to hydraulically benefit the remediation efforts. An additional 100 gpm of treated ground water may also be available for onsite use if it is not discharged to the LLNL recharge basin.

4. Additional Data and Treatability Studies

Additional data from LLNL pilot studies, a planned treatability study for the East Taxi Strip–Trailer 5475 Area, and a possible catalytic oxidation treatability study at TFF, are described in Sections 4.1 through 4.3. Section 4.4 summarizes ongoing source investigations.

4.1. Ground Water

Evaluations of extraction well and treatment facility performance during the LLNL pilot studies are discussed in Sections 4.1.1 and 4.1.2, respectively.

4.1.1. Extraction Well Performance

Ground water extraction pilot tests have been conducted at LLNL since 1989. These tests include those conducted on EW-415, in the Detailed Study Area (DSA), and in the Gasoline Spill Area. Results of these tests are summarized below.

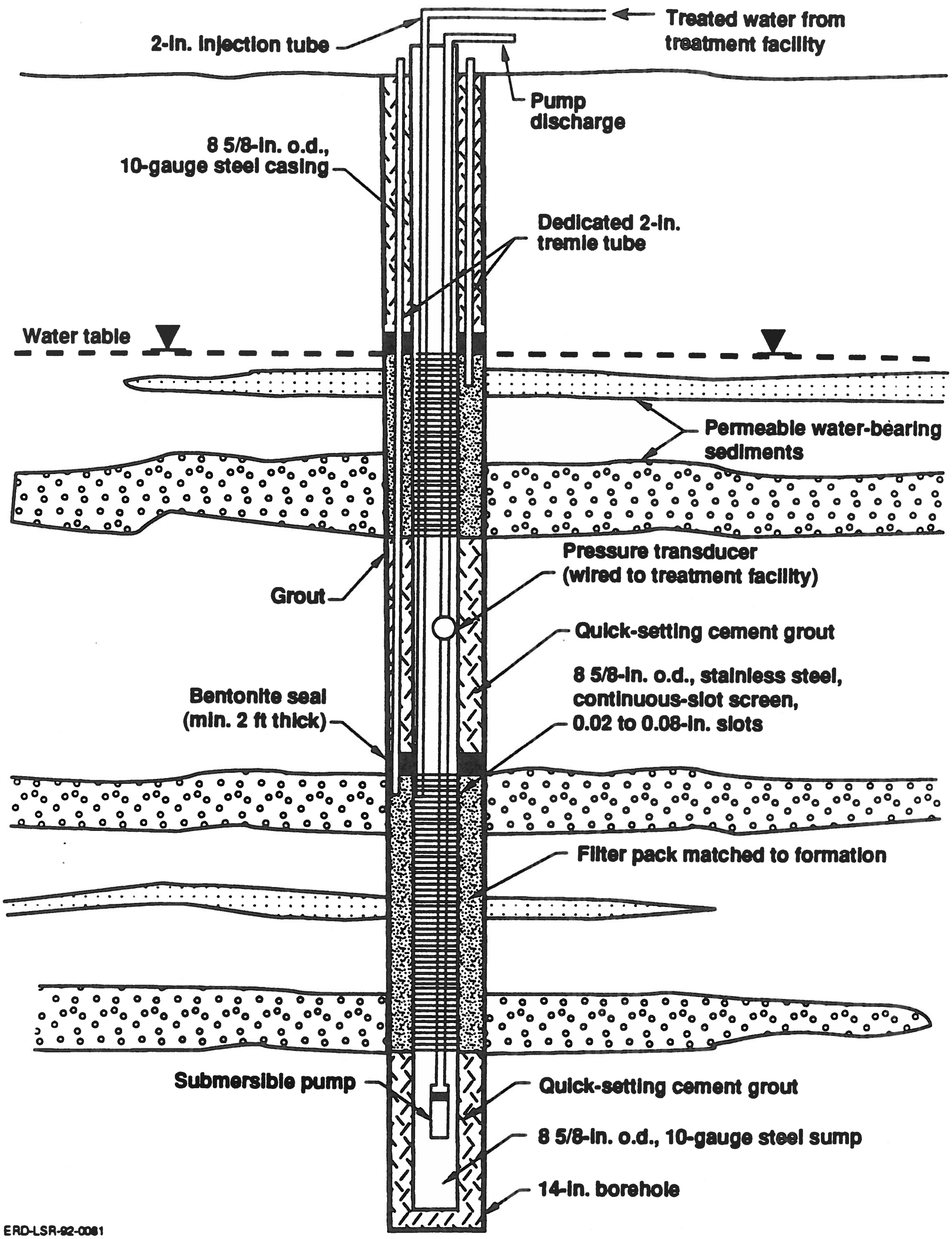


Figure 17. Schematic diagram of multizone recharge well.

4.1.1.1. Extraction Well EW-415

Extraction well EW-415 is located in the southwestern part of LLNL, at extraction location 1 on Figure 3. This well is continuously screened and sand-packed from 79 to 179 feet, over the entire thickness of the VOC plume in that location (Dresen *et al.*, 1988). Limitations of this design are described in Section 3.1.1. This design was employed because of the presence of VOCs in sediments of all grain sizes, and because of the difficulty associated with installing numerous individual grout seals between well screens over a 100-foot interval.

Hydraulic data collected in the EW-415 vicinity indicate that the well effectively captures a significant portion of the VOC plume in the area. Since pumping began, VOC concentrations in EW-415 and in surrounding wells have decreased steadily. The fully screened and sand-packed well design has shown to be effective, and may be appropriate for extraction wells installed in source areas where both coarse- and fine-grained sediments contain VOCs. This type of well is relatively easy to install, but is not as versatile as other designs, as discussed in Section 3.1.1.

4.1.1.2. Detailed Study Area (DSA)

The DSA is located west of EW-415 at extraction location 2 on Figure 3. In this area, VOCs occur predominantly in the coarse-grained sediments (sand and gravel). Some VOCs are present in fine sediments surrounding the coarse-grained sediments and have penetrated up to a few feet into the fine sediments. A cluster of 10 wells, with each well completed in one of four water-bearing zones, is present in this area. As part of the offsite pilot study, a series of three 90-hour hydraulic tests were performed on DSA monitor wells to evaluate:

- The long-term use of monitor wells as extraction wells.
- Methods to optimize VOC removal rates.
- Effects of selectively pumping individual zones.

The DSA hydraulic tests indicate that existing monitor wells can be effectively used as extraction wells, at least in the short term. In addition, test results indicated that the mass removal rates varied by at least one order of magnitude in different water-bearing zones, depending primarily on the transmissivity of the screened sediments. Time-series chemical sampling of the wells indicated that VOC concentrations declined during pumping, but rebounded several days after pumping ceased to near prepumping levels. This rebounding was probably due to resaturating dewatered VOC-bearing sediments, slow equilibration of VOCs in ground water with VOCs sorbed to aquifer materials, and changes in the quantity of inflow from regions of lower concentration.

The DSA tests showed that use of several wells screened in individual zones provides the most flexibility of the three approaches evaluated at LLNL for assessing VOC mass removal rates, and enables flow rate adjustments for individual zones over time. Therefore, at extraction locations where there is sufficient space, clusters of wells are planned, each completed in a single zone containing VOCs. This is an efficient and flexible means of ground water extraction, and is most appropriate in areas away from sources where great thicknesses of fine-grained sediments do not require remediation.

4.1.1.3. Gasoline Spill Area

GSW-16 is a pilot vapor and ground water extraction well located in the LLNL Gasoline Spill Area at location 17 on Figure 3. This well is completed in the two uppermost water-bearing zones and five unsaturated intervals. Grout seals were installed between each of the screens. This design enables isolation of one or more zones using packers for selective pumping and sampling for VOCs. Unfortunately, portions of the well screen were inadvertently blocked with grout during well installation.

The well has performed adequately during short periods of pumping, but apparently clogged during a pumping test lasting many days. The clogging may have been due to microbial fouling of the remaining open portions of the well screen and has only been observed in the Gasoline Spill Area. As discussed in Section 3.1.1, limiting the number of screens to two or three per well, and establishing a minimum seal thickness of about 7 to 10 feet, will significantly reduce the risk of grouting the well screens. Thus, LLNL plans to use the multiply-screened design where surface space is insufficient for clusters of single-zone extraction wells, and where minimum grout seal thickness of about 7 to 10 feet are appropriate.

The results of the pilot study hydraulic tests indicate that all three extraction well designs may be employed during the LLNL ground water remediation, depending on site-specific conditions. No additional testing of potential well designs is required before implementation of the remedial measures.

4.1.2. Treatment Facility Performance

4.1.2.1. Treatment Facility A Performance

TFA has been operating almost full time since September 1989. The treatment system consists of a commercially available UV-light/hydrogen peroxide (UV/H_2O_2) unit and an aeration tank system to further treat the water from the UV/H_2O_2 system. Vapors from the aeration tank pass through an activated carbon filter to ensure that no measurable VOCs are released to the air.

TFA has successfully treated approximately 40 million gallons of ground water. In an effort to conserve water, a system was designed and installed that allows treated ground water from TFA to be used by the LLNL central cooling towers near Building 325 and for LLNL landscape irrigation. This use of treated ground water has reduced LLNL's use of Hetch Hetchy water during this drought period. In 1990, 4,036,000 gallons of treated ground water was used in the cooling towers and for LLNL irrigation, with the remainder discharged to the LLNL recharge basin south of East Avenue. In 1991, most of the treated water from TFA was sent to the cooling towers.

In May 1991, TFA was shut down to upgrade the system to treat up to 150 gpm of ground water. The additional treatment capacity was necessary due to the planned addition of several more extraction wells in the southwest portion of the LLNL site, and three extraction locations offsite to the west along Arroyo Seco (locations 22, 23, and 24 in Fig. 3). Extraction from these additional wells will augment hydraulic control in the southwestern portion of the VOC plume, and mitigate potential migration of VOCs to the southwest due to agricultural pumping south of East Avenue.

4.1.2.2. Treatment Facility B Performance

At TFB, startup testing following completion of construction began in September 1990. TFB uses a UV/H_2O_2 unit similar to TFA.

Since September 1990, TFB has successfully treated 1.56 million gallons of water. Most of the water treated to date has been discharged to the north-flowing drainage ditch along the east side of Vasco Road. This ditch ultimately discharges to Arroyo Las Positas north of LLNL. Due to infiltration and evaporation, the maximum distance traveled by the discharged water is about 1,000 feet north of TFB.

In January 1992, about 20 ppb hexavalent chromium was found in the TFB effluent water in concentrations slightly above the 11-ppb maximum specified in LLNL's NPDES permit. TFB was subsequently shutdown. The sources of the chromium were determined to be from ground water containing naturally occurring chromium and leaching from the edges of peeling chromium-bearing paint in the aeration tank. The system was modified to prevent hexavalent chromium from exceeding the discharge limit, as described in Draft RD Report No. 1. Current hexavalent chromium concentrations in the TFB effluent are below 10 ppb.

4.2. Vadose Zone Soil

A possible treatability study for treatment of FHC and VOC vapor from the vadose zone by catalytic oxidation is discussed in Section 4.2.1. The results of the pilot venting tests and treatment of FHC vapor by thermal oxidation are described in Section 4.2.2.

4.2.1. Possible Catalytic Oxidation Treatability Study and Startup Test

As discussed in Section 3.2.2, LLNL may conduct a treatability study for treatment of FHCs and VOCs by catalytic oxidation. The purpose of such a treatability study and its possible components are described below. A catalytic oxidation treatability study workplan would be prepared and discussed with EPA and the other regulatory agencies prior to conducting the study. The workplan would contain a schedule and a description of the scope of the treatability study.

4.2.1.1. Purpose

The primary purposes of a catalytic oxidation treatability study would be to ensure that:

- Catalytic destruction minimizes the production of dioxin.
- Any dioxin produced is below regulatory limits.
- Destruction efficiencies are evaluated for benzene and TCE.

4.2.1.2. Treatability Study Components

The catalytic oxidation treatability study would be conducted using the catalyst manufacturer's bench-scale catalytic oxidizer (Lester, 1989). Air samples would be prepared with the benzene and TCE concentrations expected from the Gasoline Spill and Building 518 Areas. Three tests would be conducted at different catalytic oxidizer inlet temperatures. Residence times and temperature ranges for the treatability tests would be the same as expected for the full-scale catalytic oxidizer. Destruction efficiencies of benzene and TCE would be calculated for each test. The maximum potential for dioxin production would occur at the lowest temperature.

Sampling and analyses for dioxin production would be conducted for the lowest and highest temperature tests for cost-effectiveness. The samples would be analyzed by an outside laboratory. Engineering analysis of the chemical results can be extrapolated to other temperature and flow rate conditions by first-order reaction kinetics. If the performance specifications are not met by the treatability test or startup test (discussed below), LLNL may change the catalytic oxidizer design or modify the system in another way, such as adding GAC to the effluent vapor stream, to meet the performance requirements. If the treatability test indicates that catalytic oxidation will not meet the performance requirements, LLNL would continue to use GAC treatment.

4.2.1.3. Catalytic Oxidizer Startup Test

If the treatability study results warrant, a startup test of the catalytic oxidizer may be conducted to ensure performance within specifications and to assess any differences among treatability tests and the full-scale catalytic oxidizer. Sampling would be conducted to ensure that destruction efficiencies are within performance specifications. Sampling for dioxin analysis would be performed by a contract laboratory. Routine operation of the catalytic oxidizer would start only after test results show that it is operating within performance specifications. Routine operation would include analyses of benzene destruction efficiency. Continued efficient benzene destruction would indicate the catalytic oxidizer unit is achieving proper destruction efficiencies for the other hydrocarbons.

4.2.1.4. Controls and Safeguards

Process variables such as flow rate, pressure, and temperature would be monitored to ensure proper operation of the catalytic oxidizer. The catalytic reactor effluent temperature would be interlocked to the control system and atmospheric air inlet to protect the catalyst. This control system interlock would limit the influent gasoline vapor concentration to 1000 $ppm_{v/v}$, which is 10% of the lower explosive limit (LEL) of gasoline, thereby avoiding an explosion hazard. The treatability study would confirm destruction efficiency and evaluate whether dioxin is being produced. The startup test of the installed catalytic oxidizer would include evaluation of all safety equipment and destruction efficiencies, and monitoring of dioxin levels. Vapor sampling would be conducted to monitor destruction efficiency using benzene as the indicator compound. Adequate destruction efficiency of benzene will ensure no change in catalytic oxidizer efficiency. Caustic scrubber pH would be periodically checked to insure proper operation.

4.2.2. Results of Pilot Vapor Extraction and Thermal Oxidation at the Gasoline Spill Area

A pilot remediation study of gasoline vapor extraction from the vadose zone at the Gasoline Spill Area was conducted from 1988 to 1992. This study showed significant removal of gasoline from the unsaturated zone. A liquid-ring vacuum pump removed vapors from test venting well GSW-16, which is screened primarily in fine-grained sediments over five separate depth intervals in the vadose zone near the center of the fuel spill.

Extraction from one or more adjacent screened intervals was accomplished with packers. Extracted vapors were treated with a thermal oxidizer. The maximum flow rate of this system was 100 standard cubic feet per minute (scfm). Vapor extraction started August 11, 1988, from all five screened zones. During the first 245 hours of operation, the vacuum averaged 11.1 inches of mercury at a flow rate of 61.4 scfm. The total benzene, toluene, ethylbenzene, and xylene (BTEX) concentration ranged from 682 to 7,180 parts per million on a volume basis ($ppm_{v/v}$) and averaged about 2,650 $ppm_{v/v}$. Soil vapor extraction was more effective in areas of higher permeability than in areas of lower permeability (Oberdorfer and Cook, 1992). Total liquid-equivalent gasoline removed during this initial period was 406 gallons for an average removal rate of 39.8 gallons per day.

Injection of heated air into monitor well GSW-15, located 6 feet north of GSW-16, enhanced the hydrocarbon removal rate during December 1989 (Macdonald *et al.*, 1991a). Accelerated wear of packer material was also noted during the heated air injection test.

Installation of multiply-completed soil vapor monitoring points during 1990 and 1991 allowed analysis of vapor flow and FHC concentration within the surrounding sediments and helped determine which screened zones should be used for maximum gasoline removal. Vacuum was measured during vapor extraction and recovery (when extraction ceased), and soil vapors were also sampled. Extraction tests were conducted during July and August 1991 on individual screened zones, and a long-term test was conducted on the deepest two zones. Because areas of higher permeability had been substantially remediated (Oberdorfer and Cook, 1991), extraction from the areas of higher concentration and lower permeability (the lower three zones) was then conducted. Vapor extraction was restarted in November 1991. The present soil vapor extraction system is limited by the capacity of the thermal oxidizer and the liquid ring vacuum pump, rather than the physical characteristics of the subsurface sediments.

A microbiological study found the bacteria populations, including gasoline-degrading bacteria, to be much greater at the Gasoline Spill Area than nearby at an uncontaminated site on DOE property south of East Avenue (Krauter and Rice, 1991). Oxygen sampling (Camp, 1992) indicated that the oxygen concentration was near atmospheric levels at the uncontaminated site, but was greatly reduced within the Gasoline Spill Area, especially deeper in the gasoline plume. This is evidence of aerobic microbial respiration. Oxygen levels increased during vapor extraction in the Gasoline Spill Area, and then decreased when the vapor extraction system was shut down. Vapor extraction probably provides oxygen for an enhanced biodegradation rate.

Venting from GSW-16 was conducted for 247 hours during December 1991, averaging 2.4 inches of mercury vacuum at a flow rate of 40.2 scfm at the conclusion of the vapor extraction pilot test. Total BTEX concentration ranged from 197 to 676 $ppm_{v/v}$ and averaged 348 $ppm_{v/v}$. The total liquid-equivalent gasoline removed during December 1991 was 31 gallons for a removal rate of 3 gallons per day. This is about 7.5% of the initial removal rate in 1988, which indicates that significant removal of volatile compounds from the vadose zone occurred during the pilot study.

The FHC and total gasoline removal rates were high initially, but tapered off near the end of the pilot test. In all, the pilot system operated for 221 days and removed a total of 1,980 gallons of gasoline (Macdonald *et al.*, 1991a). The thermal oxidizer successfully treated the FHCs at greater than 99% efficiency. Table 3 summarizes data from the Gasoline Spill Area pilot test.

In summary, the pilot tests showed that vapor extraction by inducing a vacuum is a viable method for removing volatile hydrocarbons from the vadose zone at LLNL. Venting tests on pilot well GSW-16 indicate that screening future venting wells in moderate and high permeability sediments will increase mass removal rates. As discussed in Section 3.2.1, other technologies, such as electrical heating of the low permeability silts and clays, may be necessary to rapidly remove contaminants from low-permeability vadose zone sediments.

Table 3. Summary of data from the Gasoline Spill Area venting tests.

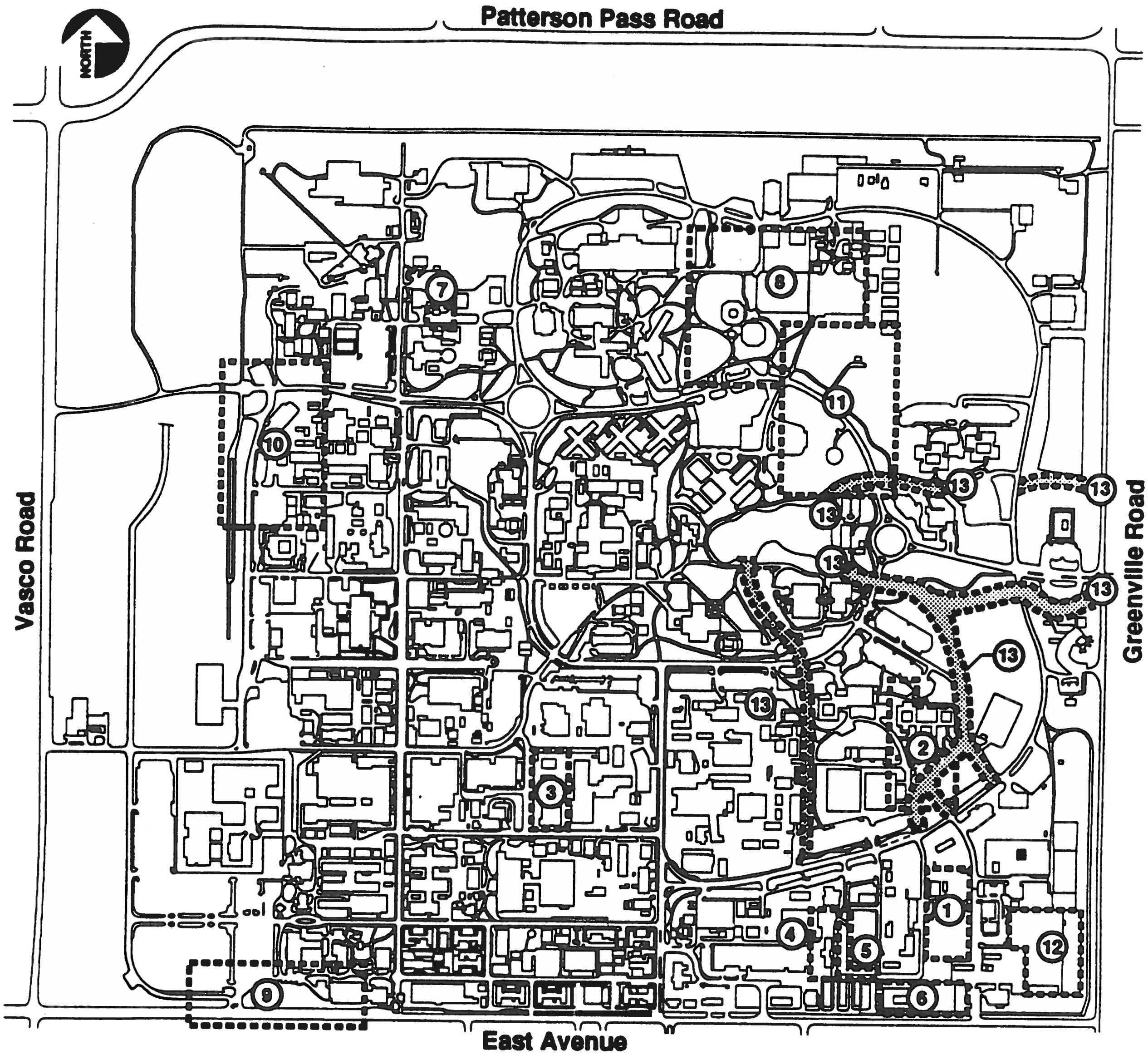
Year	Days of operation	Vacuum (inches of mercury)	Average flow (scfm)	Average concentration (ppmv)	Liquid equivalent gasoline	
					Removed (gallons)	Removal rate (gallons per day)
1988	13.7	10.6	57.3	2870	519	37.9
1989	131	12.3	50.7	1130	1280	9.77
1990	34.0	6.3	76.9	366	90.1	2.65
1991	42.3	7.1	31.3	297	88.9	2.10

4.3. East Taxi Strip–Trailer 5475 Area Treatability Study

The East Taxi Strip–Trailer 5475 Area is the only area at LLNL where both VOCs and tritium occur in ground water in concentrations above MCLs. The vadose zone in this area also contains elevated concentrations of both VOCs and tritium. As discussed in the ROD, LLNL's approach to ground water remediation in this area is to prevent removal of tritium from the subsurface and allow the tritium to decay naturally below ground while remediating the VOCs. To implement this approach, LLNL is planning to evaluate technologies that will separate the VOCs from the tritiated ground water in the subsurface. Possible technologies include 1) *in situ* air stripping of VOCs with removal of VOC vapor to the surface for treatment (Small, 1991; Herrling and Buermann, 1990), and 2) membrane separation technology (Baker *et al.*, 1991). These and other technologies will be further evaluated and one will be selected for testing during the East Taxi Strip–Trailer 5475 Area treatability study, scheduled to begin in September 1993.

4.4. Ongoing Investigations

As described in Section 2.2, LLNL is conducting source investigations at 13 locations around the LLNL site. These areas are shown in Figure 18 and listed in Table 4 in the order that LLNL plans to investigate each area. The order in Table 4 is based on current knowledge of the magnitude and type of potential sources in each area. This order may be changed and/or new areas may be added as investigations proceed, or due to logistical factors affecting the field investigations (e.g., drill rig access, weather conditions, etc.).



Legend

1. Building 612
2. East Taxi Strip/T-5475
3. Building 331
4. Building 419
5. Building 511
6. Building 518
7. Building 292
8. Building 490
9. Arroyo Seco
10. MW-501
11. Helipad
12. Salvage yard
13. Unlined drainage ditches

Scale: Feet

0 250 500 1000

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Figure 18. Remaining source investigation areas.

The areas in Table 4 consist of areas which were not completely evaluated in the RI (Thorpe *et al.*, 1989) and new areas that have been identified since the RI was issued. Prior to conducting field work in any of the remaining source areas, EPA and the other regulatory agencies are notified in writing of the planned work.

Table 4. Future source investigation areas.

Potential source area	Planned activities
1. Building 612	Boreholes to evaluate potential hazardous materials releases as part of a closure plan.
2. East Taxi Strip–Trailer 5475 Area	Boreholes to monitor movement of VOCs in the vadose zone and to characterize infiltration.
3. Building 331	Boreholes to evaluate potential tritium releases.
4. Building 419	Boreholes to evaluate potential radionuclide, metals, VOCs, and acids releases.
5. Building 511	Boreholes to evaluate potential VOC releases.
6. Building 518	Boreholes to monitor movement of VOCs in the vadose zone and to characterize infiltration.
7. Building 292	Continued monitoring of tritium movement in the vadose zone and characterization of infiltration.
8. Building 490	Boreholes to evaluate potential VOC releases.
9. Arroyo Seco	Shallow boreholes to further define extent of shallow hydrocarbons.
10. MW-501	Boreholes to evaluate potential of VOC releases. Soil vapor survey has been performed.
11. Helipad	Boreholes to evaluate potential VOC releases.
12. Salvage yard	Interviews, soil vapor survey, and boreholes to evaluate potential hazardous materials releases.
13. Unlined drainage ditches	Boreholes to evaluate potential hazardous materials releases.

5. Schedule

Table 5 and Figure 19 show the schedule for submission of the RD reports to the regulatory agencies and the community. As discussed with EPA, these dates will be enforceable under the LLNL Livermore site FFA. Table 5 also shows the estimated treatment facility startup dates, and the dates for completion of additional investigations at the Building 518 and the East Taxi Strip–Trailer 5475 Areas.

As discussed in Section 2.2, the LLNL remedial designs and remedial actions will be implemented in phases. The initial Draft Remedial Design (RD1) was submitted October 9, 1992, and covered existing Treatment Facilities A and B and associated extraction wells and piezometers. Draft RD1 also included the following items that will apply to all treatment facilities:

- The Quality Assurance/Quality Control Plan for construction.
- The Health and Safety Plan for construction, operations, and maintenance.
- Requirements for offsite shipment of hazardous waste and for project closeout.

Draft RD2 will be submitted on April 10, 1993, and will cover Treatment Facilities C and F and their associated extraction wells and piezometers. Draft RD3 will be for TFD, TFE, and the Building 518 Area Treatability Study, and will be issued on September 30, 1993. Draft RD4 will be for the East Taxi Strip–Trailer 5475 Area and will be issued on March 30, 1994. Draft RD5 will be submitted on June 1, 1994, and will cover TFG. The subsequent report review and submittal dates for each Draft RD are based on the review schedule specified in the LLNL FFA for primary documents. The startup dates for Treatment Facilities D, E, and G are one year after submission of the Draft RD for each facility. They are based on a 6-month review and design period required by LLNL Plant Engineering, which will coincide with regulatory review, followed by a 6-month period required to procure contracts and construct the facilities.

CERCLA/SARA require that substantive, continuous, physical remedial action will be implemented at a CERCLA site within 15 months of the signing of the ROD. The LLNL ROD was signed on August 5, 1992. Thus, substantive, continuous physical remedial action at LLNL must be implemented by November 5, 1993. As discussed with the regulatory agencies, this requirement will be met by accomplishing the following tasks by that date:

- Issuing this RAIP.
- Implementing continuous, full-time operation of Treatment Facilities A, B, C, and F and selected extraction wells and piezometers.
- Issuing RD1 and RD2 and the Draft version of RD3.
- Completing the characterization of, and beginning a treatability study in, the East Taxi Strip–Trailer 5475 Area.
- Issuing a Revised Community Relations Plan for the post-ROD period.

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Table 5. Schedule for LLNL Remedial Designs and Remedial Actions. (Revised February 25, 1993)

Task	Completion date
Submit Draft RD1 to regulatory agencies and the community	10-10-92[1]
Submit Draft Final RAIP to regulatory agencies	11-6-92
Issue RAIP	1-6-93[2]
Receive regulatory comments on RD1	12-10-92
Submit Draft Community Relations Plan Addendum to regulatory agencies and the community	1-31-93
Submit Draft Final RD1 to regulatory agencies	3-12-93
Begin operation of TFF	2-93
Issue RD1	4-12-93
Submit Draft RD2 to regulatory agencies, and the community	5-10-93[1]
Submit Draft Final Community Relations Plan Addendum to regulatory agencies	5-31-93
Receive regulatory comments on Draft RD2	6-25-93
Issue Community Relations Plan Addendum	6-30-93[1]
Submit Draft Final RD2 to regulatory agencies	8-10-93
Issue RD2	9-10-93[2]
Begin treatability study at T-5475	9-30-93
Submit Draft RD3 to regulatory agencies and the community	9-30-93[1]
Begin operation of TFC	10-30-93
Receive regulatory comments on Draft RD3	12-1-93
Submit Draft Final RD3 to regulatory agencies	2-1-94
Issue RD3	3-1-94[2]
Submit Draft RD4 to the regulatory agencies and the community	3-30-94[1]
Receive regulatory comments on Draft RD4	5-30-94
Submit Draft RD5 to regulatory agencies and the community	6-1-94[1]
Complete investigation of B-518	6-1-94
Submit Draft Final RD4 to regulatory agencies	7-30-94
Receive regulatory comments on Draft RD5	8-1-94

Table 5. (continued).

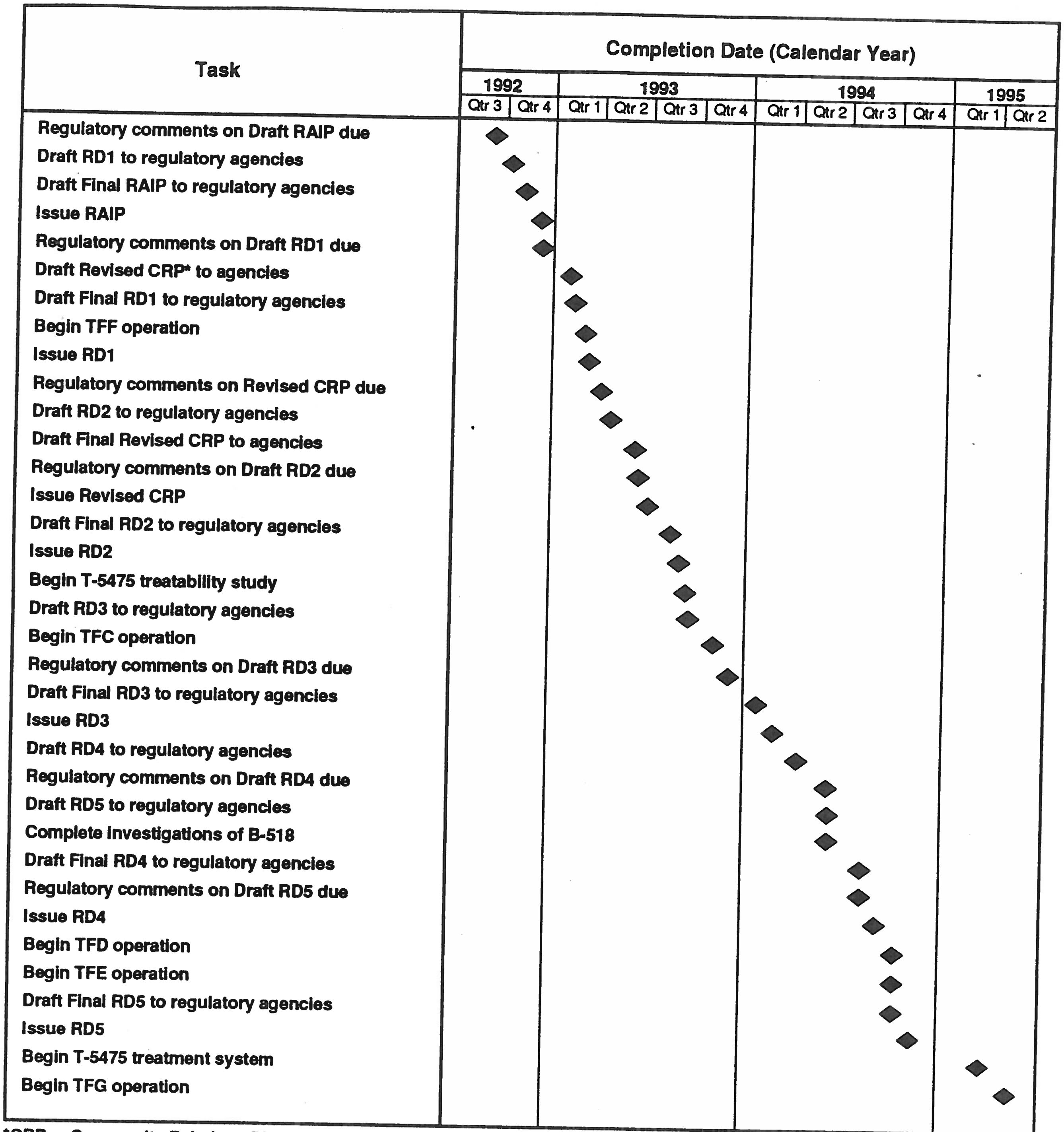
Task	Completion date
Issue RD4	8-30-94
Begin operation of TFD	9-30-94
Begin operation of TFE	9-30-94
Submit Draft Final RD5 to regulatory agencies	10-1-94
Issue RD5	11-1-94[2]
Begin operation of Trailer 5475 treatment system	3-10-95
Begin operation of TFG	5-1-95

[1]These dates are enforceable under the LLNL Livermore site Federal Facility Agreement.

[2]These dates can be met only if there are few or no comments on the Draft Final version.

Notes:

1) All primary FFA documents will be submitted to DOE 30 days prior to submission to the regulatory agencies.
2) There will be five phased Remedial Design (RD) submittals (RD1 through RD5).
3) Extraction wells will be phased-in over a 3-year period beginning in the year the treatment facility is constructed.
4) Draft RD #1 = Background information for TFA and TFB and associated extraction wells and piezometers.
5) Draft RD #2 = TFC, TFF, and associated extraction wells and piezometers.
6) Draft RD #3 = TFD, TFE, associated extraction wells and piezometers, and B-518 vapor extraction treatability study results.
7) Draft RD #4 = Trailer 5475.
8) Draft RD #5 = TFG and associated extraction wells and piezometers.



*CRP = Community Relations Plan

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Figure 19. Schedule of LLNL Remedial Designs and Remedial Actions. See Table 5 for details.

6. Post-ROD Community Relations

Community concerns and information needs have been a factor in LLNL's technical decisions since 1983, when the Ground Water Project investigations first began. During the RD and RA stages of the project, LLNL will continue to balance community concerns with significant technical, legal, and policy issues that may need to be addressed. As stated in the ROD for the Livermore site, DOE/LLNL are committed to maintain a community relations program throughout the life of the cleanup.

Many of the post-ROD community relations activities will continue to be informational in nature. Others, such as small and large group meetings, will provide an opportunity for LLNL and the community to continue the two-way exchange and dialogue established at the time that the LLNL Superfund activities first began. The nature of these activities will be determined through a community relations reassessment process that is currently underway. This process began in October 1992.

The purpose of this reassessment process is to determine such things as: community understanding of the project, community interest and information needs, and the best ways to continue working with the community as the cleanup is planned, designed, and implemented. This is accomplished through one-on-one interviews with Community Work Group (CWG) members and a broad cross section of the community. All aspects of the community relations program are being reviewed in light of information from the interviews, and the program will be revised accordingly. All of the original CWG members are being asked whether they consider the CWG to be a useful forum, how it could be improved, whether they want to continue their involvement in a similar effort, and the names of others who might be interested in this group.

Based on the information from the interviews and its own experience with the current community relations program, LLNL will revise the community relations program and meet with the current CWG to discuss the findings of the reassessment process. LLNL expects that the interview process will yield useful suggestions for improving community involvement. The results of this reassessment process will be published as an addendum to the existing Community Relations Plan, which was originally developed in 1988. This draft addendum will be submitted to the regulatory agencies and the community by January 31, 1993 (Table 5).

The community relations activities that have been ongoing since the time that the LLNL Superfund investigation first began, and which are likely to continue, include:

- **Fact Sheets.** LLNL has been writing and distributing fact sheets regarding project developments since 1988. The current format for this information is a newsletter called the Ground Water *Update,* which provides comprehensive information on the status of the project and upcoming meetings. The mailing list includes over 1,800 individuals, groups, and elected and agency officials.

  A number of CWG members have expressed an interest in information that goes beyond the scope of responsibilities of the LLNL ground water remediation. LLNL's Area Relations Department is considering a regular mailing to the public that includes information on a broad range of LLNL-related environmental topics.

- **One-on-One and Small Group Meetings.** As in the past, ground water project staff will be available to meet with interested individuals or groups on a scheduled basis. The current LLNL contact for the Ground Water Project is Pat Post (510-423-4255).

- **Community Work Group Meetings.** If the community assessment interviews show that there is sufficient community interest, DOE/LLNL will continue to support a CWG or other formal group process to assure community input. If appropriate, community group meetings would be held at least every time that LLNL/DOE submits a primary draft document to the regulatory agencies (e.g., the RD reports). Background material would be provided to group members in advance of each meeting. As in the past, LLNL will consider group and other community input in subsequent revisions of those documents.

  All community meetings would continue to be open to the public. LLNL would send out announcements of each meeting to the area newspapers in advance of the meeting date.

  LLNL/DOE met with the current CWG members following release of the Draft RAIP. Another meeting is scheduled to discuss Draft RD Report No. 1.

- **Information Line.** For over 4 years, LLNL has made staff available to handle telephone inquiries regarding Ground Water Project questions and concerns. Inquiries are directed to Pat Post at 510-423-4255. LLNL also has a community hotline for other information: 510-422-9797.

- **Information Repositories/Administrative Record.** Since 1988, LLNL has established and maintained two locations where the public can review key documents produced by the project or other LLNL staff. The *Monthly Progress Reports,* which contain information on the status of project activities, are also included in these repositories. If there is evidence of any new contamination sources on the Livermore site, or evidence of any unusual contaminant migration, this information would be included in the *Monthly Progress Reports*.

- **Meetings with TAG Advisors.** LLNL has been interacting with the Technical Advisors hired by Tri-Valley CAREs pursuant to EPA's Technical Assistance Grant (TAG) program, since 1989. Those interactions have taken the form of written responses to questions, conversations at CWG meetings, and one all-day meeting initiated in July 1991 by DOE/LLNL.

  Because LLNL recognizes the value of working with the Technical Advisors as the project moves into the post-ROD phase, LLNL suggested a process to Tri-Valley CAREs whereby ground water project and DOE staff would meet with the Technical Advisors following the release of draft and final documents. The Technical Advisors were invited to submit written comments to LLNL at least several weeks prior to each of those meetings, to give LLNL/DOE time to consider questions. Tri-Valley CAREs was invited to have a representative at these meetings. The goal is to have these meetings within 30 days following the release of project documents, to provide sufficient time to incorporate Technical Advisor concerns, as appropriate, into subsequent drafts. The first such meeting took place on September 3, 1992.

- **Tours.** LLNL has provided a number of tours of ground water project facilities to CWG members, the press, and other interested members of the public. These tours will continue to be available during the RD and RA stages of the project. LLNL's Area Relations Department is expanding its environmental tour program and expects to make this tour a regularly scheduled offering to the public in 1993.

- **Public Meetings and Public Comment Periods.** LLNL would conduct a public comment period, and offer the opportunity for a public meeting, if any new contamination is found at the Livermore site requiring a cleanup approach that is significantly different from that outlined in the ROD.

- **On October 24, LLNL sponsored an Environmental Day.** The event featured exhibits and tours designed to inform and educate the public on all aspects of LLNL's environmental cleanup and compliance activities, as well as innovative environmental research and technology development.

In summary, the nature and timing of future community relations activities will be determined during the community relations reassessment process. The program will be documented in the Revised Community Relations Plan. LLNL/DOE are committed to working with the community throughout the life of the remediation, and will continually seek to adjust the community relations program to meet the changing needs of the community.

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